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MISCELLANEOUS PAPERS.

# BIOLOGICAL STUDIES ON THREE SPECIES OF APHIDIDÆ.

By JOHN JUNE DAVIS,
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# MISCELLANEOUS PAPERS.

## BIOLOGICAL STUDIES ON THREE SPECIES OF APHIDIDÆ.

By John June Davis,

*Of the University of Illinois, Urbana, Ill.*

### INTRODUCTION.

This paper deals principally with the biology of three of our commoner species of aphides, and includes descriptions of the different forms in all their various stages, as well as a complete bibliography of these species.

I have carried on these rearing experiments for the past two years in the insectary of the State entomologist of Illinois, Dr. S. A. Forbes. Practically all of the data here given, however, were obtained in 1906.

I am especially under obligations to Doctor Forbes, under whose direction I have made the experiments—those relating to *Aphis maidi-radicis* while serving as his assistant; to Dr. J. W. Folsom, who has aided me on all parts of this paper, and to Prof. F. M. Webster, who read the manuscript and made helpful suggestions.

### THE CORN ROOT-APHIS.

(*Aphis maidi-radicis* Forbes.)

#### GENERAL ACCOUNT.

The corn root-aphis was first recognized by Benjamin Dann Walsh, who found it, in 1862, at Rock Island, Ill., where it was doing considerable damage to a small field of corn. At that time it was supposed by Mr. Walsh to be a root form of the common corn leaf-aphis (*Aphis maidis* Fitch), which lives on the upper parts of the corn plant, while the corn root-aphis, as the name would indicate, lives on the roots.

Dr. S. A. Forbes first began the study of this root-aphis in 1883, and most of the facts now known relating to its life history, ecology,

and economic control have been obtained by him or under his supervision. When he began the study of this aphis, it was believed to be merely the root form of the corn leaf-aphis. Failing after many elaborate experiments to breed either from the other, and repeatedly tracing the complete life history of the root-aphis year after year with no appearance of the leaf-aphis at any time in the series, he regarded the corn root-aphis as a distinct species, and described it as such in 1891, in the Seventeenth Report of the State Entomologist of Illinois.

The insect has, of late years, become of great economic importance, not only in Illinois, but also in many other States of the corn belt. Outside of Illinois it has been reported as injuring corn in New York, New Jersey, Maryland, Virginia, West Virginia, Ohio, Indiana, Minnesota, Iowa, Missouri, Nebraska, Kentucky, Mississippi, Louisiana, and Colorado.

## FOOD PLANTS.[a]

Although corn is its principal food plant, the corn root-aphis attacks also sorghum and broom corn; has been reported as attacking the roots of squash vines in Delaware and Ohio, and what is at present considered as this species has been found on the roots of numerous weeds and grasses, namely, smartweed (*Polygonum incarnatum*), knotweed (*P. persicaria*), crab grass (*Panicum*), purslane (*Portulaca oleracea*), dock (*Rumex crispus* and *R. altissimus*), *Setaria glauca*, *S. viridis*, *S. germanica*, fleabane (*Erigeron canadense*), mustard (*Brassica nigra*), sorrel (*Oxalis stricta*), plantain (*Plantago major* and *P. rugellii*), pigweed (*Amarantus hybridus*), and ragweed (*Ambrosia trifida*). In May, 1907, Mr. E. O. G. Kelly found it on wheat roots in a field which had been in corn the previous year. It has also been collected on the roots of cultivated aster, upon which I have found it to be of much economic importance in Illinois.

## LIFE HISTORY.

Last year (1906) I obtained the complete life history of this corn root-aphis from the egg stage in spring to the egg in autumn. The vivaria which I used for the rearing and observation of this root aphis consisted of 8-dram or 10-dram glass vials, each containing a ball of moist cotton in the bottom and plugged at the top with a piece of cotton. In this cage a sprouting corn plant was placed, a reserve supply of these food plants being constantly kept for use. The first young and the last young of each generation were placed on corn roots in separate vials, and these vials were kept in closed boxes to exclude

[a] The scientific names of plants throughout this paper are given according to the nomenclature of Gray, in deference to the author's wishes.—ED.

light, thus giving conditions probably most favorable to the optimum development of the aphis. As soon as the plant began to wilt it was replaced by a fresh one, the aphides being transferred thereto by means of a camel's-hair brush.

During the life cycle of this aphis there appear five different forms, namely, winged viviparous females, wingless viviparous females, oviparous females, males, and eggs. Briefly, the life history is as follows: From the eggs, which have been found hatching in the field between April 8[a] and May 22, from 10 to 22 generations may follow. These generations are all viviparous from spring until the latter part of September or in October, according to conditions of temperature, etc. The last generation of the season is known as the oviparous generation, and consists of males—wingless only, so far as known—and oviparous wingless females. The males and females pair, and the females lay eggs, usually during the months of October and November, the eggs not hatching until the following spring.

Now follows a detailed account of the life history as worked out by me in 1906. Eggs collected at Elliott, Ill., April 12, 1906, in the nests of the common brown ant (*Lasius niger* L., var. *americanus* Emery) were placed in a cage in our insectary April 16. They were first noticed to be hatching April 17. Young aphides hatching April 18 and 19 were placed on corn roots in the previously-described vials, and two lines of generations were thus started, both of which were carried through to the egg in the fall. These stem mothers—that is, the aphides hatching from the egg—produced their first young May 1 and 4, respectively, and their last young May 18 and 14, respectively. Taking the *first young of the first young* all the way through the series, 22 generations were obtained, counting the oviparous generation as the last. (See Tables I and II.)

[a] In 1906 Mr. E. O. G. Kelly, a field assistant of the State entomologist of Illinois, searched for eggs and young of *A. maidi-radicis* in the fields, beginning the 1st of April. He did not find eggs until April 12, and on April 17 he found the young stem mothers in the field. The following year Mr. Kelly first found eggs March 24 (these hatched in the insectary March 26), and young stem mothers were found in ants' nests as early as March 29. April 15 he found the young with their beaks inserted in old corn roots, this probably being occasioned by the fact that large numbers of the weeds upon which the aphis usually feeds at this season had been killed by the very cold weather of the preceding week.

TABLE I.—*Line of generations of Aphis maidi-radicis from egg to oviparous generation, 1906.*

| Generation (from egg). | Date of birth. | Date it became adult. | Date of first young. | Age at birth of first young. | Date of last young. | Productive period. | Life after last young. | Number of young. | Average young per day of productive period. | Largest number of young in one day. | Date of death or disappearance. | Total length of life. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | *Days.* | | *Days.* | *Days.* | | | | | *Days.* |
| 1..... | Apr. 18 | Apr. 30 | May 1 | 13 | May 18 | 17 | 2 | 96 | 5.6 | 10 | May 20 | 32 |
| 2..... | May 1 | May 12 | May 13 | 12 | May 27 | 14 | 6 | 74 | 5.3 | 10 | June 2 | 32 |
| 3..... | May 13 | May 19 | May 21 | 8 | May 30 | 9 | 1 | 53 | 6.6 | 9 | May 31 | 18 |
| 4..... | May 21 | May 27 | May 29 | 8 | June 4 | 6 | 0 | 31 | 5.3 | 7 | June 6 | 14 |
| 5..... | May 29 | June 5 | June 6 | 8 | June 24 | 18 | 8 | 89 | 4.9 | 9 | July 2 | 34 |
| 6..... | June 6 | June 14 | June 15 | 9 | July 2 | 17 | 9 | 76 | 4.4 | 7 | July 11 | 35 |
| 7..... | June 15 | June 22 | June 23 | 8 | July 25 | 2 | 0 | 7 | 3.5 | 4 | June 25 | 10 |
| 8..... | June 23 | ..... | June 30 | 7 | July 15 | 15 | 0 | 74 | 4.9 | 7 | July 15 | 22 |
| 9..... | June 30 | July 7 | July 8 | 8 | July 11 | 3 | 0 | 22 | 7.3 | 7 | July 11 | 11 |
| 10..... | July 8 | July 14 | July 15 | 7 | July 23 | 8 | 0 | 53 | 6.6 | 7 | July 23 | 15 |
| 11..... | July 15 | July 22 | July 22 | 7 | July 24 | 2 | 0 | 7 | 3.5 | ..... | July 24 | 9 |
| 12..... | July 22 | July 29 | July 30 | 8 | Aug. 8 | 9 | 1 | 51 | 5.1 | 8 | Aug. 9 | 17 |
| 13..... | July 30 | Aug. 5 | Aug. 5 | 6 | Aug. 9 | 5 | 0 | 24 | 4.8 | 6 | Aug. 9 | 15 |
| 14..... | Aug. 5 | Aug. 12 | Aug. 12 | 7 | Aug. 16 | 4 | 0 | 17 | 4.2 | 6 | Aug. 16 | 11 |
| 15..... | Aug. 12 | Aug. 18 | Aug. 19 | 7 | Aug. 24 | 6 | 0 | 33 | 5.5 | 8 | Aug. 24 | 13 |
| 16..... | Aug. 19 | ..... | Aug. 27 | 8 | Sept. 9 | 14 | 0 | 66 | 4.7 | 10 | Sept. 9 | 22 |
| 17..... | Aug. 28 | ..... | Sept. 5 | 8 | Sept. 8 | 3 | 0 | 13 | 4 + | 6 | Sept. 8 | 11 |
| 18..... | Sept. 5 | ..... | Sept. 12 | 7 | Sept. 20 | 9 | 1 | 28 | 3 + | 6 | Sept. 21 | 17 |
| 19..... | Sept. 13 | Sept. 19 | Sept. 20 | 7 | Sept. 27 | 8 | 1 | 41 | 5 + | 9 | Sept. 28 | 16 |
| 20..... | Sept. 21 | Sept. 28 | Sept. 30 | 9 | Oct. 2 | 3 | 0 | 10 | 3 + | 4 | Oct. 2 | 12 |
| 21..... | Sept. 30 | Oct. 13 | Oct. 14 | 14 | Nov. 2 | 19 | 5 | 29 | 1.5 | ..... | Nov. 7 | 38 |
| 22[a].... | Oct. 14 | Oct. 27 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | {Nov. 22– / Nov. 23} | 39 |

[a] Oviparous generation.

TABLE II.—*Line of generations of Aphis maidi-radicis from egg to oviparous generation, 1906.*

| Generation (from egg). | Date of birth. | Date of becoming adult. | Date of first young. | Age at birth of first young. | Date of last young. | Productive period | Life after last young. | Number of young. | Average young per day of productive period. | Largest number of young in one day. | Date of death or disappearance. | Total length of life. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | *Days.* | | *Days.* | *Days.* | | | | | *Days.* |
| 1..... | Apr. 19 | May 2 | May 4 | 15 | May 14 | 10 | 1 | 36 | 3.6 | 6 | May 15 | 26 |
| 2..... | May 4 | May 15 | May 16 | 12 | June 4 | 19 | 5 | 64 | 3.4– | 8 | June 9 | 36 |
| 3..... | May 16 | May 23 | May 24 | 8 | June 2 | 9 | 0 | 50 | 5.5+ | 8 | June 2 | 17 |
| 4..... | May 24 | June 1 | June 2 | 9 | June 9 | 7 | 1 | 41 | 5.8– | 7 | June 10 | 17 |
| 5..... | June 2 | June 8 | June 9 | 7 | June 17 | 8 | 1 | 40 | 5. | 8 | June 18 | 16 |
| 6..... | June 9 | June 17 | June 18 | 9 | June 29 | 11 | 0 | 58 | 5.2+ | 8 | June 29 | 20 |
| 7..... | June 18 | June 26 | June 27 | 9 | July 8 | 11 | 0 | 65 | 5.9+ | 8 | July 8 | 20 |
| 8..... | June 27 | July 3 | July 4 | 7 | July 13 | 9 | 0 | 38 | 4.2+ | 5 | July 13 | 13 |
| 9..... | July 4 | July 11 | July 11 | 7 | July 14 | 3 | 0 | 12 | 4. | 6 | July 14 | 11 |
| 10..... | July 11 | July 18 | July 19 | 8 | July 31 | 12 | 0 | 66 | 3.3 | 8 | July 31 | 20 |
| 11..... | July 19 | July 25 | July 26 | 7 | Aug. 10 | 15 | 3 | 70 | 4.7– | 8 | Aug. 13 | 25 |
| 12..... | July 26 | Aug. 1 | Aug. 2 | 7 | Aug. 10 | 9 | 1 | 46 | 5.1+ | 8 | Aug. 11 | 16 |
| 13..... | Aug. 2 | Aug. 8 | Aug. 9 | 7 | Aug. 21 | 14 | 1 | 63 | 4.5 | 6 | Aug. 22 | 22 |
| 14..... | Aug. 9 | Aug. 15 | Aug. 16 | 7 | Aug. 27 | 12 | 0 | 58 | 3. + | 8 | Aug. 27 | 19 |
| 15..... | Aug. 16 | ..... | Aug. 22 | 6 | Aug. 24 | 3 | 0 | 13 | 4. + | 6 | Aug. 24 | 9 |
| 16..... | Aug. 22 | Aug. 29 | Aug. 30 | 8 | Sept. 7 | 9 | 1 | 42 | 4.6+ | 7 | Sept. 8 | 18 |
| 17..... | Aug. 30 | Sept. 6 | Sept. 7 | 8 | Sept. 23 | 17 | 0 | 40 | 2. + | 5 | Sept. 23 | 25 |
| 18..... | Sept. 7 | Sept. 13 | Sept. 14 | 7 | Sept. 21 | 8 | 2 | 13 | 1. + | 5 | Sept. 23 | 17 |
| 19..... | Sept. 14 | Sept. 21 | Sept. 22 | 8 | Sept. 23 | 2 | 0 | 4 | 2. | 2 | Sept. 23 | 10 |
| 20..... | Sept. 22 | Oct. 1 | Oct. 2 | 10 | Oct. 22 | 13 | 16 | 29 | 2. + | 4 | Nov. 7 | 39 |
| 21..... | Oct. 2 | Oct. 15 | Oct. 17 | 15 | Oct. 29 | 15 | ..... | 29 | 1. – | 8 | ..... | (*d*) |
| 22[a].... | Oct. 17 | {[b]Oct. 24 / [c]Nov. 5} | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |

[a] Oviparous generation. These aphides were removed to other cages when they became adult.
[b] 1 oviparous female. [c] 2 male. [d] Not less than 30 days.

On the other hand, beginning with the last to be borne by the aphis which hatched April 18, and following down the series of the last borne of each generation, there were but 11 generations. From this it

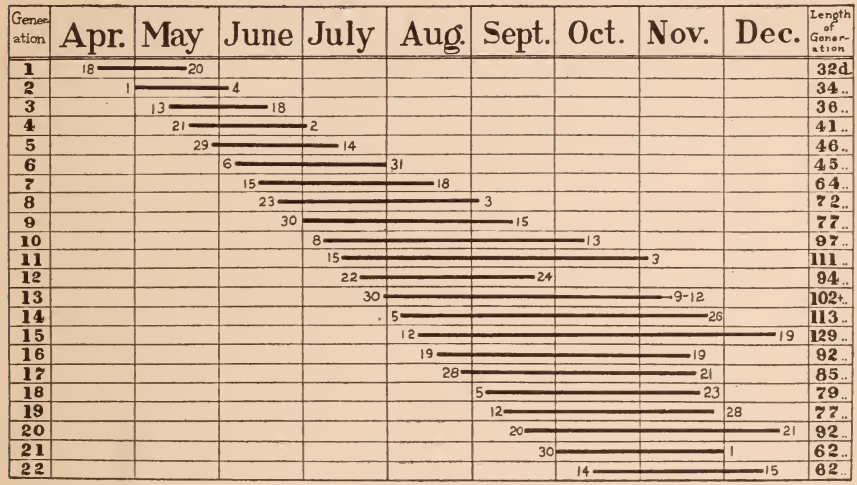


FIG. 31.—Periods and succession of generations in *Aphis maidi-radicis*, 1906.

follows that the mean number of complete generations for the year is 16½. The first generation extended over a period of 31 days, from April 18 to May 20; the second, 34 days; and the third, 36 days (figs.

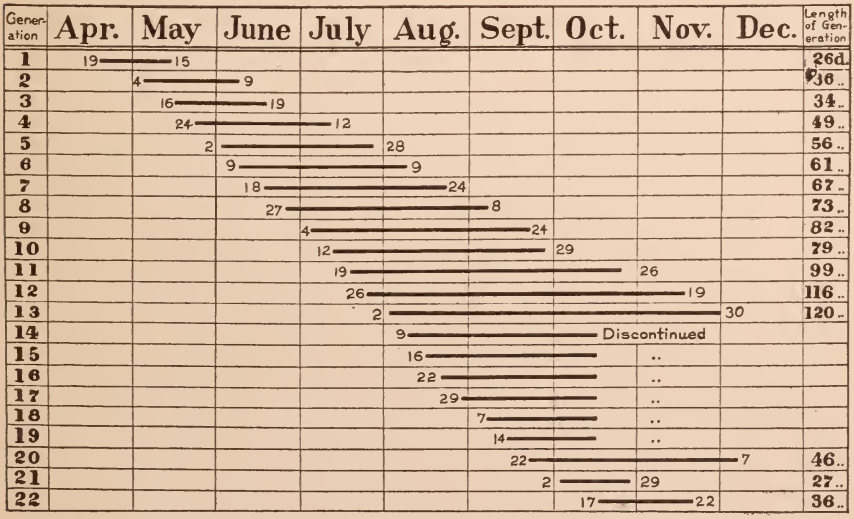


FIG. 32.—Periods and succession of generations in *Aphis maidi-radicis*, 1906.

31, 32). The fifteenth generation proved to be the longest, continuing for 129 days. Then the period of each generation diminished gradually. These data, however, were taken from only one line of genera-

tions—that is, the generations obtained from a single stem-mother, isolated in the spring. If we take into consideration the time during which eggs have been found hatching in the field—from April 8 until May 22, a period of 44 days—it will be seen that each of the generations might occur in the field much longer than my insectary experiments would indicate. On May 1 individuals of the first 2 generations coexisted in the insectary; on June 1, 4 generations, from the second to the fifth, inclusive; on July 1, 6 generations, from the fourth to the ninth; on August 1, 7 generations, from the seventh to the thirteenth; on September 1, 10 generations, from the eighth to the seventeenth; on September 12, 11 generations, from the ninth to the nineteenth; and between September 30 and October 24 there were 12 generations in existence, from the tenth to the twenty-first, this being the largest number of generations in existence at any one time. (See figs. 31, 32.) From that date on, the number of generations in existence at any one time rapidly diminished until December 21, at which time all of the aphides were dead. The latest date of birth in a viviparous generation was October 7, and the last survivor of this generation died November 28. The first record of the bisexual oviparous generation in the insectary, in 1906, was October 2, and eggs were found a few days later. Young of this generation were born as late as November 4, and aphides were still alive December 21. However, in 1905 I found individuals of this oviparous generation as early as September 5; also, they were observed in copula, and eggs were found as early as September 30. Bisexual forms may appear in any generation, providing the environmental conditions are such as to favor their development. Thus, in the insectary sexual forms appeared in October and November from 12 different generations, varying from the eleventh to the twenty-second, inclusive, thus indicating that the appearance of the sexes may be conditioned by the temperature. This is illustrated by the occurrence of sexual forms on September 5, 1905, at which time the weather was quite cool for that time of the year, although in 1906 the sexual forms did not appear until October 2, the weather up to that time being milder than in 1905. Between April 2, 1890, and January 17, 1893, Prof. M. V. Slingerland carried *Myzus achyrantes* Monell through 62 generations by keeping the temperature uniform. Although further experiments would be necessary for positive proof, still, from what is now known, it appears that with the necessary conditions for the development of young—food and heat—the aphides would be able to reproduce parthenogenetically for an indefinite period. Numerous records were made by me of instances in which the first young were viviparous and the last oviparous. In these cases it was noticed that after the production of viviparous forms the aphis would rest a few days before beginning to produce the sexual forms.

VIVIPAROUS GENERATION.

In 1906, between April 18 and October 3, 128 individual experiments were carried on with viviparous females, and the following averages are taken from the entire number of experiments (see Table III):

TABLE III.—*Data of individual experiments with Aphis maidi-radicis, viviparous generation, 1906.*

| Date of birth. | Date of becoming adult. | Date of first young. | Age at birth of first young. | Date of last young. | Productive period. | Life after last young. | Number of young. | Average young per day of productive period. | Largest number of young for one day. | Date of death. | Total length of life. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | *Days.* | | *Days.* | *Days.* | | | | | *Days.* |
| Apr. 18 | Apr. 30 | May 1 | 13 | May 18 | 17 | 2 | 96 | 5.6 + | 10 | May 20 | 32 |
| Apr. 19 | May 2 | May 4 | 15 | May 14 | 10 | 1 | 36 | 3.6 | 6 | May 15 | 26 |
| May 1 | May 12 | May 13 | 12 | May 27 | 14 | 6 | 74 | 5.3 − | 10 | June 2 | 32 |
| May 4 | May 15 | May 16 | 12 | June 4 | 19 | 5 | 64 | 3.4 − | 8 | June 9 | 36 |
| May 13 | May 19 | May 21 | 8 | May 30 | 9 | 1 | 53 | 6.6 + | 9 | May 31 | 18 |
| May 14 | May 23 | May 24 | 10 | June 1 | 8 | 1 | 35 | 4 − | 7 | June 2 | 19 |
| May 16 | ...do..... | ...do..... | 8 | June 2 | 9 | 0 | 50 | 5.5 + | 8 | ...do..... | 17 |
| May 18 | ..... | May 26 | 8 | June 4 | 9 | 0 | 42 | 4.6 + | 10 | June 4 | 17 |
| May 21 | May 27 | May 29 | 8 | ...do..... | 6 | 0 | 31 | 5.3 + | 7 | June 6 | 14 |
| May 24 | ..... | June 2 | 9 | June 15 | 13 | 0 | 58 | 4.4 + | 7 | June 15 | 22 |
| Do.... | June 1 | ...do..... | 9 | June 9 | 7 | 1 | 41 | 5.8 − | 7 | June 10 | 17 |
| May 26 | June 4 | June 4 | 9 | ...do..... | 5 | 0 | 33 | 6.6 | 8 | June 9 | 14 |
| May 29 | June 5 | June 6 | 8 | June 24 | 18 | 8 | 89 | 4.9 + | 9 | July 2 | 34 |
| May 31 | ..... | June 8 | 8 | June 19 | 11 | 0 | 34 | 3 + | 7 | June 19 | 19 |
| June 2 | June 8 | June 9 | 7 | June 17 | 8 | 1 | 40 | 5 | 8 | June 18 | 16 |
| June 3 | June 9 | June 10 | 7 | June 16 | 6 | 2 | 24 | 4 | 5 | ...do..... | 15 |
| June 4 | June 12 | June 14 | 10 | June 29 | 15 | 2 | 73 | 4.8 + | 10 | July 1 | 27 |
| June 6 | June 14 | June 15 | 9 | July 2 | 17 | 9 | 76 | 4.4 + | 7 | July 11 | 35 |
| June 8 | June 17 | June 18 | 10 | ...do..... | 14 | 0 | 62 | 4.4 + | 9 | July 2 | 24 |
| June 9 | ...do..... | ...do..... | 9 | June 29 | 11 | 0 | 58 | 5.3 − | 8 | June 29 | 20 |
| June 10 | ..... | ...do..... | 8 | ...do..... | 11 | 2 | 51 | 4.6 + | 7 | July 1 | 21 |
| Do.... | June 19 | June 20 | 10 | July 1 | 11 | 8 | 48 | 4.3 + | 7 | July 9 | 29 |
| Do.... | June 18 | June 19 | 9 | June 30 | 11 | 2 | 72 | 2 | 11 | July 2 | 22 |
| June 14 | June 21 | June 22 | 8 | ...do..... | 8 | 0 | 53 | 6.6 + | 10 | June 30 | 16 |
| June 6 | June 16 | June 18 | 12 | June 25 | 7 | 0 | 21 | 3 | 6 | June 25 | 19 |
| June 18 | June 27 | June 27 | 9 | July 4 | 7 | 3 | 37 | 5.2 + | 8 | July 7 | 19 |
| Do.... | June 26 | ...do..... | 9 | July 8 | 11 | 0 | 65 | 5.9 + | 8 | July 8 | 20 |
| Do.... | ..... | June 26 | 8 | July 2 | 6 | 1 | 45 | 7 + | 9 | July 3 | 15 |
| Do.... | June 25 | ...do..... | 8 | July 1 | 5 | 0 | 29 | 5.8 | 10 | July 1 | 13 |
| June 19 | June 26 | June 28 | 9 | July 13 | 15 | 0 | 44 | 3 − | 8 | July 13 | 24 |
| Do.... | ...do..... | June 27 | 8 | July 5 | 8 | 1 | 51 | 6.3 + | 10 | July 6 | 17 |
| June 20 | ..... | June 28 | 8 | July 8 | 10 | 1 | 50 | 5 | 8 | July 9 | 19 |
| June 22 | June 29 | June 30 | 8 | July 11 | 11 | 0 | 62 | 5.6 + | 8 | July 11 | 19 |
| June 23 | ..... | ...do..... | 7 | July 15 | 15 | 0 | 74 | 4.9 + | 7 | July 15 | 22 |
| June 27 | ..... | July 4 | 7 | July 10 | 6 | 0 | 29 | 4.8 + | 8 | July 10 | 13 |
| Do.... | July 3 | ...do..... | 7 | July 13 | 9 | 0 | 38 | 4.2 + | 8 | July 13 | 13 |
| Do.... | July 2 | July 3 | 6 | July 16 | 13 | 0 | 59 | 4.5 + | 9 | ...do..... | 19 |
| June 28 | July 6 | July 6 | 8 | July 15 | 9 | 1 | 48 | 5.3 + | 7 | July 16 | 18 |
| June 30 | July 7 | July 8 | 8 | July 11 | 3 | 0 | 22 | 7.3 + | 7 | July 11 | 11 |
| July 3 | July 10 | July 11 | 8 | July 20 | 9 | 0 | 44 | 4.9 + | 7 | July 20 | 17 |
| July 4 | July 11 | July 12 | 8 | ...do..... | 8 | 1 | 42 | 5.2 + | 8 | July 21 | 17 |
| July 6 | July 12 | July 13 | 7 | July 24 | 11 | 1 | 52 | 4.7 + | 7 | July 25 | 19 |
| July 8 | July 13 | July 14 | 6 | July 27 | 13 | 10 | 64 | 4.9 + | 8 | Aug. 6 | 29 |
| Do.... | July 14 | July 15 | 7 | July 23 | 8 | 0 | 53 | 6.6 + | 7 | July 23 | 15 |
| Do.... | ...do..... | July 14 | 6 | July 25 | 11 | 0 | 56 | 5 + | 9 | July 25 | 17 |
| July 11 | July 17 | July 18 | 7 | July 24 | 7 | 1 | 49 | 7 | 10 | ...do..... | 14 |
| Do.... | July 18 | July 19 | 8 | July 31 | 12 | 0 | 66 | 3.3 | 8 | July 31 | 20 |
| July 12 | ...do..... | ...do..... | 7 | July 28 | 9 | 0 | 54 | 6 | 8 | July 28 | 16 |
| July 13 | July 21 | July 21 | 7 | July 29 | 8 | 1 | 44 | 5.5 | 7 | July 30 | 16 |
| Do.... | July 18 | July 19 | 6 | ...do..... | 10 | 2 | 45 | 4.5 | 7 | July 31 | 18 |
| July 14 | July 21 | July 21 | 7 | July 27 | 6 | 0 | 25 | 4.1 + | 8 | July 27 | 13 |
| Do.... | ...do..... | July 22 | 8 | Aug. 1 | 10 | 0 | 62 | 6.2 | 10 | Aug. 1 | 18 |
| July 18 | July 23 | July 24 | 6 | July 29 | 5 | 0 | 29 | 5.8 | 8 | July 29 | 11 |
| July 19 | July 25 | July 26 | 7 | Aug. 10 | 15 | 3 | 70 | 4.7 | 8 | Aug. 13 | 25 |
| Do.... | ...do..... | ...do..... | 7 | Aug. 4 | 9 | 1 | 55 | 6.1 + | 7 | Aug. 5 | 17 |
| Do.... | ...do..... | ...do..... | 7 | Aug. 5 | 10 | 0 | 51 | 5.1 | 7 | ...do..... | 17 |
| July 21 | July 28 | July 28 | 7 | Aug. 6 | 9 | 2 | 47 | 5.2 + | 8 | Aug. 8 | 18 |
| Do.... | ...do..... | July 29 | 8 | Aug. 3 | 5 | 0 | 30 | 6 | 9 | Aug. 3 | 13 |
| July 22 | ...do..... | ...do..... | 7 | Aug. 6 | 8 | 0 | 46 | 5.7 + | 8 | Aug. 6 | 15 |
| Do.... | July 29 | July 30 | 8 | Aug. 8 | 9 | 1 | 51 | 5.1 | 8 | Aug. 9 | 17 |

TABLE III.—*Data of individual experiments with Aphis maidi-radicis, viriparous generation, 1906*—Continued.

| Date of birth. | Date of becoming adult. | Date of first young. | Age at birth of first young. | Date of last young. | Productive period. | Life after last young. | Number of young. | Average young per day of productive period. | Largest number of young for one day. | Date of death. | Total length of life. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | *Days.* | | *Days.* | *Days.* | | | | | *Days.* |
| July 26 | Aug. 1 | Aug. 2 | 7 | Aug. 10 | 9 | 1 | 46 | 5.1 + | 8 | Aug. 11 | 16 |
| Do | do | do | 7 | Aug. 8 | 7 | 0 | 49 | 7 | 8 | Aug. 8 | 14 |
| Do | do | do | 7 | Aug. 9 | 8 | 0 | 43 | 5.3 + | 9 | Aug. 9 | 15 |
| July 27 | Aug. 2 | do | 6 | do | 8 | 0 | 46 | 5.7 + | 10 | do | 14 |
| July 28 | | Aug. 5 | 8 | Aug. 14 | 9 | 0 | 46 | 5.1 + | 6 | Aug. 14 | 17 |
| July 29 | Aug. 4 | do | 7 | Aug. 11 | 6 | 1 | 35 | 5.8 + | 8 | Aug. 12 | 14 |
| July 30 | Aug. 5 | do | 6 | Aug. 9 | 5 | 0 | 24 | 4.8 | 6 | Aug. 9 | 15 |
| July 29 | Aug. 4 | do | 7 | Aug. 18 | 13 | 0 | 55 | 4.2 + | 9 | Aug. 18 | 20 |
| Aug. 1 | Aug. 7 | Aug. 7 | 6 | Aug. 13 | 6 | 1 | 37 | 6 + | 8 | Aug. 14 | 13 |
| Aug. 2 | Aug. 8 | Aug. 9 | 7 | Aug. 21 | 14 | 1 | 63 | 4.5 | 6 | Aug. 22 | 22 |
| Do | Aug. 7 | Aug. 8 | 6 | Aug. 15 | 7 | 0 | 45 | 6.4 + | 9 | Aug. 15 | 13 |
| Aug. 5 | Aug. 13 | Aug. 13 | 8 | Aug. 22 | 9 | 0 | 44 | 4.8 + | 8 | Aug. 22 | 17 |
| Do | Aug. 12 | do | 8 | Aug. 19 | 7 | 0 | 31 | 4.4 + | 5 | Aug. 19 | 14 |
| Do | Aug. 11 | Aug. 12 | 7 | Aug. 22 | 10 | 0 | 54 | 5.4 | 8 | Aug. 22 | 17 |
| Do | do | do | 7 | Aug. 18 | 6 | 1 | 35 | 5.8 + | 8 | Aug. 19 | 14 |
| Aug. 7 | Aug. 15 | Aug. 15 | 8 | Aug. 26 | 11 | 0 | 50 | 4.5 + | 9 | Aug. 26 | 19 |
| Aug. 9 | do | Aug. 16 | 7 | Aug. 24 | 8 | 0 | 41 | 5.1 + | 8 | Aug. 24 | 15 |
| Do | do | do | 7 | Aug. 27 | 12 | 0 | 58 | 3 + | 8 | Aug. 27 | 19 |
| Do | Aug. 17 | Aug. 17 | 8 | Aug. 23 | 6 | 0 | 31 | 5.1 + | 7 | Aug. 23 | 14 |
| Aug. 12 | Aug. 19 | Aug. 19 | 7 | Aug. 29 | 10 | 0 | 48 | 4.8 | 7 | Aug. 29 | 17 |
| Aug. 13 | do | Aug. 20 | 7 | do | 9 | 0 | 60 | 6.6 + | 9 | do | 16 |
| Aug. 12 | Aug. 18 | Aug. 19 | 7 | Aug. 24 | 6 | 0 | 33 | 5.5 | 8 | Aug. 24 | 13 |
| Aug. 15 | Aug. 21 | Aug. 22 | 7 | Sept. 2 | 11 | 0 | 51 | 4.6 + | 9 | Sept. 2 | 18 |
| Aug. 16 | Aug. 22 | Aug. 23 | 7 | do | 10 | 0 | 56 | 5.6 | 7 | do | 17 |
| Aug. 17 | Aug. 23 | do | 6 | do | 10 | 0 | 47 | 4.7 | 7 | do | 16 |
| Do | do | do | 7 | Sept. 3 | 11 | 0 | 49 | 4.4 + | 6 | Sept. 3 | 18 |
| Aug. 19 | Aug. 26 | Aug. 26 | 7 | Sept. 5 | 10 | 0 | 47 | 4.7 | 7 | Sept. 5 | 17 |
| Do | do | Aug. 27 | 8 | Sept. 15 | 19 | 0 | 48 | 2.5 + | 8 | Sept. 15 | 27 |
| Do | | do | 8 | Sept. 9 | 14 | 0 | 66 | 4.7 + | 10 | Sept. 9 | 22 |
| Aug. 20 | Aug. 25 | Aug. 26 | 6 | Sept. 3 | 8 | 0 | 42 | 6 | 7 | Sept. 3 | 14 |
| Aug. 22 | Aug. 29 | Aug. 30 | 8 | Sept. 8 | 9 | 1 | 50 | 5.5 + | 6 | Sept. 9 | 18 |
| Do | do | do | 8 | Sept. 7 | 9 | 1 | 42 | 4.6 + | 7 | Sept. 8 | 18 |
| Aug. 23 | Aug. 31 | Aug. 31 | 8 | Sept. 10 | 10 | 2 | 51 | 5.1 | 7 | Sept. 12 | 20 |
| Do | do | do | 8 | Sept. 6 | 7 | 2 | 34 | 4.8 + | 7 | Sept. 8 | 17 |
| Do | | Sept. 2 | 10 | Sept. 15 | 13 | 1 | 56 | 4.2 + | 7 | Sept. 16 | 24 |
| Aug. 24 | | do | 9 | Sept. 8 | 6 | 0 | 27 | 4.5 | 6 | Sept. 8 | 15 |
| Aug. 26 | | do | 7 | Sept. 10 | 8 | 0 | 40 | 5 | 8 | Sept. 10 | 15 |
| Aug. 28 | Sept. 4 | Sept. 4 | 7 | Sept. 9 | 5 | 0 | 24 | 4.8 | 5 | Sept. 9 | 12 |
| Aug. 30 | Sept. 7 | Sept. 7 | 8 | Sept. 12 | 5 | 0 | 22 | 4.5 | 7 | Sept. 12 | 13 |
| Do | Sept. 6 | do | 8 | Sept. 23 | 16 | 0 | 40 | 2.4 + | 5 | Sept. 23 | 24 |
| Aug. 31 | Sept. 7 | Sept. 8 | 8 | Sept. 19 | 11 | 0 | 23 | 2 + | 6 | Sept. 19 | 19 |
| Do | Sept. 8 | Sept. 9 | 9 | Sept. 21 | 12 | 0 | 23 | 2 − | 5 | Sept. 21 | 21 |
| Sept. 2 | Sept. 10 | Sept. 11 | 9 | Sept. 16 | 5 | 0 | 23 | 4.6 | 5 | Sept. 16 | 14 |
| Do | do | do | 9 | Sept. 17 | 6 | 1 | 33 | 5.5 | 7 | Sept. 18 | 16 |
| Sept. 4 | Sept. 11 | do | 7 | Sept. 28 | 17 | 2 | 49 | 2.8 + | 6 | Sept. 30 | 26 |
| Do | do | do | 7 | Sept. 19 | 8 | 1 | 37 | 4.6 + | 6 | Sept. 20 | 16 |
| Sept. 5 | | Sept. 12 | 7 | Sept. 20 | 9 | 1 | 28 | 3 + | 6 | Sept. 21 | 17 |
| Sept. 7 | Sept. 14 | Sept. 15 | 8 | Sept. 25 | 10 | 0 | 41 | 4.1 | 7 | Sept. 25 | 18 |
| Sept. 11 | Sept. 18 | Sept. 19 | 8 | Sept. 26 | 7 | 0 | 35 | 5 | 9 | Sept. 26 | 15 |
| Do | Sept. 19 | do | 8 | Sept. 24 | 6 | 0 | 30 | 5 | 9 | Sept. 24 | 14 |
| Sept. 13 | do | Sept. 20 | 7 | Sept. 27 | 8 | 1 | 41 | 5 + | 9 | Sept. 28 | 16 |
| Sept. 15 | Sept. 22 | Sept. 23 | 8 | Oct. 6 | 14 | 0 | 32 | 2.2 + | 5 | Oct. 6 | 22 |
| Sept. 16 | do | Sept. 22 | 6 | Oct. 7 | 16 | 6 | 23 | 1.4 + | 4 | Oct. 13 | 28 |
| Sept. 17 | Sept. 25 | Sept. 25 | 8 | Oct. 15 | 20 | 6 | 28 | 1.5 | 4 | Oct. 22 | 34 |
| Sept. 18 | Sept. 24 | do | 7 | Oct. 8 | 14 | 2 | 25 | 1.7 + | 4 | Oct. 10 | 23 |
| Sept. 19 | Sept. 25 | Sept. 26 | 7 | do | 13 | 3 | 20 | 1.5 + | 5 | Oct. 11 | 23 |
| Do | Sept. 26 | Sept. 27 | 8 | Oct. 17 | 20 | 7 | 56 | 2.8 | 7 | Oct. 27 | 35 |
| Sept. 20 | Sept. 27 | do | 7 | Oct. 15 | 18 | 1 | 52 | 2.8 + | 5 | Oct. 16 | 26 |
| Sept. 22 | Oct. 1 | Oct. 2 | 10 | Oct. 22 | 20 | 18 | 29 | 1.4 + | 4 | Nov. 7 | 48 |
| Do | Sept. 30 | Oct. 1 | 9 | Oct. 17 | 16 | 3 | 21 | 1.3 + | 7 | Oct. 21 | 28 |
| Do | Sept. 29 | do | 9 | Nov. 2 | 32 | 1 | 35 | 1 + | 4 | Nov. 3 | 42 |
| Sept. 27 | Oct. 7 | Oct. 9 | 12 | Oct. 31 | 22 | 8 | 26 | 1.1 + | 4 | Nov. 9 | 42 |
| Sept. 30 | Oct. 13 | Oct. 14 | 14 | Nov. 2 | 18 | 5 | 29 | 1.6 + | 4 | Nov. 7 | 36 |
| Sept. 26 | Oct. 5 | Oct. 6 | 10 | Oct. 24 | 14 | 3 | 21 | 1.5 | 3 | Oct. 27 | 27 |
| Oct. 2 | Oct. 15 | Oct. 17 | 15 | Oct. 29 | 12 | ..... | 29 | 2.4 + | 8 | ..... | 27 |
| Do | Oct. 13 | Oct. 15 | 13 | Oct. 24 | 9 | 2 | 22 | 2.4 + | 4 | Oct. 26 | 24 |
| Do | Oct. 14 | do | 13 | do | 9 | 0 | 23 | 2.5 + | 5 | Oct. 24 | 22 |
| Oct. 3 | Oct. 16 | Oct. 17 | 14 | Nov. 26 | 40 | 2 | 49 | 1.2 + | 3 | Nov. 28 | 56 |
| Total | | | 1,044 | | 1,367 | | 5,651 | 570.82 | | | 2,573 |
| Average | | | 8.1+ | | 10.6+ | | 44.1+ | 4.4+ | | | 20.1+ |

The immature stage was found to be quite variable in length, covering from 6 to 15 days, with an average of 8.1+ days. This is approximately the same as that obtained from experiments of 1905, in which, from 97 records, the average length of this nymphal period was 8.3+ days. During the first few generations and also the last generation the time from the birth of an aphis until the birth of its first young was much longer than it was during the warmer summer months. The time between the birth of the first and that of the last young likewise varied considerably, being from 3 to 40 days, the period being noticeably longer in early spring and in the fall. The average for the entire year was 10.6+ days. Usually the female would live several days after the production of her last young. The entire length of life of the aphis varied between 11 and 56 days, with an average for the year of 20.1+ days. During the summer months the aphides, as a rule, had a shorter life and produced more young than in the cooler days of the year. The average number of young per female for the year was 44.1+. The variation in the number of young was from 20 to 96, the latter number being the largest number produced by a single female. For the year the average number of young brought forth by an individual female in a single day was 4.4+, the largest number being 11. However, in 1905 as many as 12 were born in one day from one female. The average number of young from April 18 until September 1 was, in 102 experiments, 4.9+; from September 1 to October 3 the average for 26 experiments was 2.4+ young per day, or one-half as many. It may be noted, in passing, that, as the records made in 97 experiments in 1905 vary only slightly from those obtained in the 128 experiments of 1906, the figures here given are probably sufficiently accurate for any year.

In 1905 a very interesting incident was observed. A wingless aphis taken in the field June 23 was placed in an insectary cage, and within the next few days gave birth to 6 young. It then discontinued the production of young for several days, then molted, became winged, and produced 21 more young.

Buckton, in his "Monograph of British Aphides," Volume I, page 87, says:

> Several early observers have erroneously stated that the female aphis is at different periods of her life both viviparous and oviparous. The acuteness of Newport failed him when he concluded "that aphides"—meaning the same individual—"deposit at one time true ova and at others produce living young." * * * It may be pretty certainly asserted that the viviparous aphis is never oviparous, and that the converse also is true.

In one experiment in 1906 an aphis born October 6 became adult October 24 and gave birth to a single young November 2, but did not produce any more young, and soon died. Upon an examination of her body only eggs were found.

All my aphides which were reared individually, in vials, were wingless. Other aphides, however, of the same mothers, and placed in cages containing many other aphides as well as a less abundant food supply, often became winged. In Science, Volume XXI, January 27, 1903, pages 48–49, Prof. M. V. Slingerland gives an account of rearing individually 62 generations of *Myzus achyrantes* during a period of 2 years and 10 months, only wingless agamic females being produced. From these and other evidences obtained it may be inferred that the development of the winged forms among aphides is largely caused by an insufficient food supply.

The number of molts is invariably four, the time of occurrence of the different molts being shown in Table IV.

TABLE IV.—*Periods of molts of Aphis maidi-radicis, viviparous generation, 1906.*

| Date of birth. | Age at first molt. | Age at second molt. | Age at third molt. | Age at fourth molt. | Age at birth of first young. |
|---|---|---|---|---|---|
| | *Days.* | *Days.* | *Days.* | *Days.* | *Days.* |
| April 18 | 4 | 8 | 10 | 12 | 13 |
| April 19 | 5 | 8 | 10 | 13 | 15 |
| May 1 | 2 | 4 | 7 | 11 | 12 |
| May 4 | 3 | 6 | 8 | 11 | 12 |
| May 13 | 2 | 3 | 4 | 6 | 8 |
| May 21 | 2 | 3 | 4 | 6 | 8 |
| June 27 | 1 | 2 | 4 | 6 | 7 |
| June 28 | 1 | 3 | 6 | 8 | 8 |

As a rule, reproduction did not begin until the next day after the fourth molt, though it sometimes occurred within a few hours after the molt. Often in the last generations, in autumn, reproduction did not begin until two days after the last molt.

### OVIPAROUS GENERATION.

The oviparous generation was found in the insectary, in 1906, from October 2 to December 21. Records of 47 individuals of this generation were obtained (Table V); the records, however, are not complete in all cases. The length of the immature stage—from birth to adult—varied from 10 to 39 days, this latter being a very exceptional record.

TABLE V.—*Data of individual experiments with Aphis maidi-radicis, oviparous generation, 1906.*

| Date of birth. | Date of maturity. | Age at maturity. | Date of death. | Age at death. | Number of eggs laid. | Number of eggs in body at death. | Total number of eggs. | Sex. |
|---|---|---|---|---|---|---|---|---|
| | | *Days.* | | *Days.* | | | | |
| October 6 | Oct. 21 | 15 | Nov. 5 | 30 | 10 | 1 | 11 | Female. |
| Do | Oct. 22 | 16 | ...do | 30 | | | | Male. |
| October 8 | Oct. 24 | 16 | Nov. 14 | 37 | 4 | 2 | 6 | Female. |
| Do | ...do | 16 | Nov. 10 | 33 | | | | Male. |
| October 9 | Oct. 22 | 13 | [a]Oct. 26 | [b]17 | | | | Female. |
| Do | ...do | 13 | [a]Nov. 2 | [b]24 | | | | Do. |
| October 15 | Oct. 31 | 16 | Nov. 28 | 44 | 7 | 2 | 9 | Do. |
| October 7 | Oct. 20 | 13 | Oct. 22 | 15 | | | | Do. |
| October 15 | Nov. 3 | 19 | [a]Nov. 23 | [b]39 | | | | Male. |
| October 17 | Nov. 5 | 19 | Nov. 8 | 22 | | | | Do. |
| October 15 | Oct. 31 | 16 | [a]Oct. 31 | [b]16 | | | | Do. |
| Do | ...do | 16 | [a]Nov. 2 | [b]18 | | | | Do. |
| Do | Nov. 1 | 17 | [a]Nov. 9 | [b]25 | | | | Do. |
| October 13 | Oct. 27 | 14 | Nov. 12 | 30 | | | | Do. |
| October 29 | Nov. 24 | 26 | Dec. 11 | 43 | | | | Female. |
| October 15 | Oct. 29 | 14 | Nov. 15 | 31 | 3 | 2 | 5 | Do. |
| October 22 | Nov. 11 | 20 | Nov. 26 | 35 | | | | Male. |
| October 13 | Oct. 23 | 10 | [a]Oct. 29 | [b]16 | | | | Female. |
| Do | ...do | 10 | ..do.[a] | [b]16 | | | | Do. |
| October 20 | Nov. 7 | 18 | Nov. 12 | 23 | | | | Male. |
| October 19 | Oct. 29 | 10 | [a]Nov. 2 | [b]13 | | | | Female. |
| October 20 | Nov. 1-2 | 12-13 | ..do.[a] | [b]13 | | | | Do. |
| October 21 | ...do | 12-13 | ..do.[a] | [b]13 | | | | Do. |
| October 26 | Nov. 17 | 22 | Dec. 1 | 36 | | | | Male. |
| Do | Dec. 4 | 39 | Dec. 15 | 50 | | | | Female. |
| October 24 | Nov. 7 | 14 | Nov. 30 | 37 | | | | Do. |
| October 21 | Nov. 8-9 | 18-19 | [a]Nov. 14 | [b]24 | | | | Do. |
| Do | ...do | 18-19 | ..do.[a] | [b]24 | | | | Do. |
| October 24 | Nov. 10-11 | 17-18 | ..do.[a] | [b]21 | | | | Do. |
| Do | Nov. 16-17 | 23-24 | Dec. 5 | 43 | | | | Do. |
| November 2 | Nov. 21 | 19 | Dec. 5 | 33 | | | | Do. |
| Do | ...do | 19 | Dec. 19 | 47 | | | | Do. |
| October 6 | Oct. 20 | 14 | [a]Oct. 25 | [b]19 | | | | Do. |
| Do | ...do | 14 | [a]Oct. 26 | [b]20 | | | | Do. |
| Do | ...do | 14 | [a]Oct. 27 | [b]21 | | | | Do. |
| Do | ...do | 14 | ..do.[a] | [b]21 | | | | Do. |
| October 7 | ...do | 13 | Nov. 21 | 43 | | | | Do. |
| October 9 | Oct. 21 | 12 | [a]Oct. 28 | [b]19 | | | | Do. |
| Do | ...do | 12 | Nov. 12 | 34 | 3 | 8 | 11 | Do. |
| Do | Oct. 24 | 15 | [a]Oct. 29 | [b]20 | | | | Do. |
| Do | ...do | 15 | ..do.[a] | [b]20 | | | | Do. |
| Do | ...do | 15 | ..do.[a] | [b]20 | | | | Do. |
| Do | ...do | 15 | Oct. 31 | 22 | | | | Do. |
| Do | ...do | 15 | [a]Nov. 3 | [b]25 | | | | Do. |
| Do | ...do | 15 | ..do.[a] | [b]25 | | | | Do. |
| October 12 | ...do | 12 | Nov. 23 | 42 | 4 | 6 | 10 | Do. |
| October 16 | Oct. 31 | 15 | ...do | 38 | 3 | 5 | 8 | Do. |
| October 18 | Nov. 3-4 | 16-17 | Dec. 1 | 44 | 2 | 5 | 7 | Do. |

[a] Removed. [b] Age when removed.

The average of 47 records is 16+ days. The average total life of 38 individuals was 30.9+ days, with a maximum (1906) of 50 days. In 1905 one aphis of this oviparous generation lived to the age of 61 days. A few records were made as to the number of eggs laid by individual females, and this was found to vary up to 10, which was probably not far from the actual number that is ordinarily laid, though 4 was the average number in the counts made. Eggs were found in the bodies of nearly all the females after death; the potential reproductive capacity of the female seems to exceed her vitality.

It is easy to distinguish immature males from oviparous females after the second molt by their color. The males have a distinct reddish hue, while the females have a greenish color.

The number of molts in the oviparous generation is four, as in the viviparous generation. From Table VI, showing the periods between the molts, it appears that the males are more deliberate in their growth and require a longer time than the females for their full development.

TABLE VI.—*Periods of molts of Aphis maidi-radicis, oviparous generation, 1906.*

| Date of birth. | Age at first molt. | Age at second molt. | Age at third molt. | Age at fourth molt. | Period from birth to adult. | Sex. |
|---|---|---|---|---|---|---|
| | *Days.* | *Days.* | *Days.* | *Days.* | *Days.* | |
| October 11 | 3 | 5 | 9 | 13 | 13 | Female. |
| Do | 3 | 5 | 9 | 13 | 13 | Do. |
| Do | 3 | 5 | 9 | 14 | 14 | Do. |
| October 16 | 4 | 6 | 11 | 20 | 20 | Do. |
| October 17 | 2 | 5 | 9 | 13 | 13 | Do. |
| Do | 3 | 6 | 10 | 21 | 21 | Male. |
| October 21 | 4 | 9 | 14 | 21 | 21 | Do. |
| Do | 3 | 8 | 14 | 23 | 23 | Do. |
| October 22 | 5 | 9 | 13 | 16 | 16 | Female. |

## DESCRIPTIONS.[a]

### *Aphis maidi-radicis* Forbes.

#### VIVIPAROUS GENERATION.

*Before first molt and less than 1 hour old.*—General color pale pea-green. Legs and antennæ colorless and transparent. Eyes red. Measurements: Length of body, 0.882 mm.; width, 0.400 mm.; antenna, 0.327 mm.

*After first molt and not more than 24 hours old.*—General color pea-green. Antennæ almost transparent, excepting last segment, which is darker. Only 5 noticeable segments in the antennæ. Eyes red. Tip of beak darkened. Legs almost transparent, excepting tarsi, which are almost black. Cornicles small, slightly darkened at tip. Measurements: Length of body, 0.927 mm.; width, 0.509 mm.; antenna, 0.339 mm.

*After second molt and 72 to 96 hours old.*—General color pea-green. Ultimate segment of antennæ dark. Eyes reddish brown. Legs darker than body color. Tip of abdomen dark. Cornicles dark, being darkest at apex, short and very slightly incrassate in middle. Measurements: Length of body, 1.418 mm.; width, 0.709 mm.;

[a] In giving the number of segments of the antennæ I have not, as most writers do, counted the filament as a separate and distinct segment. There is certainly no articulation between the thickened basal portion and the filament of this last segment; and, thus, they can not be referred to as distinct segments.

The measurements, and the observations on colors, were taken from live specimens unless otherwise stated. Color terms are according to Ridgway's "Nomenclature of Colors."

antenna (alcoholic specimen), I, 0.040 mm.; II, 0.040 mm.; III, 0.101 mm.; IV, 0.050 mm.; V, basal, 0.061 mm.; filament, 0.098 mm.; total, 0.390 mm.

*After third molt.*—General color light chromium-green. Head with pale brownish tint. Ultimate and part of the penultimate segments of the antennæ darkened. Antenna with only 5 distinct segments; a slight constriction in the third shows the commencing of the formation of another segment. Eyes reddish brown. Legs dark, the tarsus and distal ends of the femur and tibia being almost black. Tip of abdomen dark, as are also the cornicles, which are darkest at the apex. Cornicles noticeably longer than in preceding stages; basal half more or less swollen and the tip slightly dilated. Measurements: Length of body, 2.063 mm.; width, 0.981 mm.; cornicles, 0.127 mm.; antenna (alcoholic specimens), I, 0.064 mm.; II, 0.064 mm.; III, 0.183 mm.; IV, 0.067 mm.; V, basal, 0.071 mm.; filament, 0.112 mm.; total, 0.561 mm.

*Adult wingless viviparous female.*—Head black. Thoracic and first abdominal segments with median transverse black markings, the prothorax being almost entirely black. On each side of the abdomen are 2 parallel rows of minute black markings—one on each side of the cornicle. These rows are not constant, the upper one sometimes being indistinct or wanting. Posterior 3 segments of abdomen with black transverse median markings. Eyes reddish brown. All of antenna dusky except the third segment. Cornicles and tips of style black. Coxæ, most of the femora, apex of tibiæ, and the tarsi black. Measurements: Length of body, 2.09 mm.; width, 1.036 mm.; antenna, I, 0.036 mm.; II, 0.054 mm.; III, 0.181 mm.; IV, 0.091 mm.; V, 0.091 mm.; VI, basal, 0.109 mm.; filament, 0.118 mm.; total, 0.680 mm.

*Winged viviparous female.*—Head black, thorax blackish, abdomen pale green, with a black marking on each side of the second, third, and fourth segments; transverse black markings on the last 2, and sometimes last 3, segments; a black ring around each cornicle, and a few small black markings irregularly scattered over abdomen. Antennæ dark; usually 7 or 8 sensoria on the third segment, sometimes only 6; 1 sensorium near the apex of each of the fourth and fifth segments; several more or less distinct sensoria at the apex of the basal portion of the sixth. Eyes dark reddish-brown. Cornicles and style as in wingless pseudogynes. Measurements (alcoholic specimens): Length of body, 1.468 mm.; width, 0.605 mm.; length of wing, 2.33 mm.; antenna, I, 0.036 mm.; II, 0.055 mm.; III, 0.187 mm.; IV, 0.095 mm.; V, 0.106 mm.; VI, basal, 0.099 mm.; filament, 0.194 mm.; total, 0.772 mm.

OVIPAROUS GENERATION.

*Before first molt and less than 24 hours old.*—General color pea-green. Beak not reaching beyond the coxæ of the third pair of legs, apical segment dark. Antennæ colorless, except last segment, which is darker than the remainder. Eyes black. Legs pale, except the tarsi, which are black. Measurements: Length of body, 0.954 mm.; width, 0.486 mm.; antenna, I, 0.038 mm.; II, 0.038 mm.; III, 0.114 mm.; IV, 0.153 mm.; total 0.343 mm.

*After first molt and 5 to 6 days old.*—General color dirty pea-green, with very slight tinge of red. Last segment of antenna dark. Tarsi black. Measurements: Length of body, 1.145 mm.; width, 0.573 mm.

*Oviparous female after third molt.*—Color of head and first thoracic segment very dark green. Remainder of body slate-gray, with a reddish tint. The bloom which covers the body gives to the aphis the grayish color. Tips of antennæ dark. Tarsi black. Cornicles darker than body color, with a black ring at the base of each. Measurements: Length of body, 1.985 mm.; width, 1.050 mm.

*Adult wingless oviparous female.*—General color plumbeous, which is due to the bloom covering the body. Head black, and first thoracic segment very dark beneath the bloom. Abdomen tinged with pink. In alcoholic specimens from which the bloom has been removed, the markings as in the pseudogynes, except that the black markings on the last 3 abdominal segments are not present. Antennæ dark, with one large circular sensorium near the apical end of the fifth segment, and several at the apical end of the thickened base of the sixth. Beak reaching beyond the middle coxæ. Eyes black. Legs dark; the hind tibiæ noticeably swollen and thickly covered with small circular sensoria. Cornicles black and of the same shape as in the pseudogynes. Apical half of style dark. Measurements: Length of body, 2.201 mm.; width, 1.218 mm.; antenna, I, 0.038 mm.; II, 0.047 mm.; III, 0.172 mm.; IV, 0.076 mm.; V, 0.095 mm.; VI, basal, 0.100 mm.; filament, 0.154 mm.; total, 0.682 mm.

*Male after third molt.*—Head and first thoracic segment pale green, between pea-green and sage-green. Abdomen drab. Measurements: Length of body, 1.546 mm.; width, 0.687 mm.

*Adult wingless male.*—Head black. Thoracic segments each with a transverse black marking, this giving the thorax a blackish appearance. Similar but shorter markings occur on the first 3 and the last 3 abdominal segments. The spots on the sides of the body are arranged in more or less uniform rows. Third antennal segment with 12 or more sensoria irregularly distributed, most numerous near the apex; fourth with 5 to 7 sensoria; fifth with 2 to 4 similar sensoria and a larger one near the apex; and several at apex of the basal part of the sixth. Eyes black. Antennæ, legs, and cornicles

black. Measurements (alcoholic specimens): Length of body, 1.636–1.745 mm.; width, 0.909–0.945 mm.; antenna, I, 0.081 mm.; II, 0.054 mm.; III, 0.200 mm.; IV, 0.136 mm.; V, 0.100 mm.; VI, basal, 0.109 mm.; filament, 0.181 mm.; total, 0.861 mm.; cornicle, 0.082 mm.

*Eggs.*—Elliptical-oval, yellow or greenish when first laid, gradually darkening to a jet-black. In spring just before hatching the eggs change from black to pale green. Length, 0.782 mm.; width, 0.391 mm.

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Lists *Aphis maidis* as being found on the tassel, ear-stalks, and roots of Indian corn.

*1878.* THOMAS, CYRUS.—Seventh Report of the State Entomologist of Illinois. <App.: Trans. Dept. Agr. Ill. for 1877, Springfield, Vol. XV, pp. 75–78, fig. 18 (I, III, IV). Separate: Springfield, Ill., 1878.

Gives characteristics of the aerial and root forms as presented by Fitch and Walsh, and also a description of specimens which he obtained the previous summer from a different part of the plant (tassels). Possible treatment against aphides in small patches of corn is given. Appends notes from correspondents concerning serious damage done to corn in 1874 and 1877 in Menard and Stark counties, Illinois.

*1879.* THOMAS, CYRUS.—Eighth Report of the State Entomologist of Illinois. <App.: Trans. Dept. Agr. Ill. for 1878, Springfield, Vol XVI, pp. 89–91, fig. 14 (I, III, IV). Separate: Springfield, Ill., 1879.

Same as in Seventh Report of the State Entomologist of Illinois, except that no remedies are mentioned (*loc. cit.*).

[a] This bibliography is practically complete, and contains a number of references not found in the Bibliography of Economic Entomology, by Henshaw and Banks. Those titles which have been inaccessible are marked with an asterisk. Those which are considered the most important have the date preceding them in italics.

1880. Thomas, Cyrus.—Ninth Report of the State Entomologist of Illinois. <App.: Trans. Dept. Agr. Ill. for 1879, Springfield, Vol. XVII, pp. 2–3.

Mentions both aerial and root forms (especially the latter) of the corn aphis as being quite injurious the past season (1879). Recommends rotation of crops, thorough fall plowing, and turning under strong lime.

1882. Boardman, E. R.—Corn-aphis. <Stark County (Ill.) News, December 21, 1882.

General life history of the root form; remedies.

1882. Boardman, E. R.—Economic Entomology. <Stark County (Ill.) News, December 28, 1882.

Additional notes on the life history of the corn root-aphis.

1883. Forbes, S. A.—A lecture on insects affecting corn. <Bloomington, Ill., pp. 12–14, figs. I, III, IV.

Gives known life history of both aerial and root forms of the corn aphides; also relation of ants to the corn root-aphis.

1883. Forbes, S. A.—Twelfth Report of the State Entomologist of Illinois <App.: Trans. Dept. Agr. Ill. for 1882, Springfield, Vol. XX, pp. 5–6, 44.

The corn plant-louse (probably referring to the root form) was destructive to corn the previous year (1883). Transferring of *Aphis maidis* by ants is mentioned.

*1884.* Forbes, S. A.—Thirteenth Report of the State Entomologist of Illinois. <App.: Trans. Dept. Agr. Ill. for 1883, Springfield, Vol. XXI, pp. 46–50, Pl. IV, fig. 13. Separate: Springfield, Ill., 1884.

The root-aphis makes its first appearance upon corn underground late in May or early in June, attacking not only the roots, but likewise the sprouting stem underground. Winged root form was collected May 22 and at several dates in June. It continues to be abundant throughout the month of July. Obtained on sorghum roots July 26 and 31. October 8 was the last date at which it was found. Next year (1883) the first winged root-aphides were obtained June 7 and again July 29. Rotation is given as a remedy.

1884. Forbes, S. A.—Circular on the corn root-aphis and Hessian fly. <Ill. Crop Prospects, Springfield, May, 1884, p. 48. Reprint: Farmers' Review, Chicago, Ill., June 5, 1884. See Prairie Farmer, Chicago, Ill., June 14, 1884.

Requests for information concerning injuries by *Aphis maidis* (?), root form.

*1885.* Garman, H.—A contribution to the life history of the corn plant-louse. <Fourteenth Rep. State Ent. Ill., Springfield, pp. 23–33. Same: Trans. Dept. Agr. Ill., Springfield, Ill., Vol. XXII, 1885.

Previous literature, descriptions of the root and aerial forms, life history, parasitic and predaceous insects, and artificial remedies.

1886. Forbes, S. A.—Notes on the past year's work. <Can. Ent., London, Ont., Vol. XVIII, p. 176. Also: Ent. Amer., Brooklyn, N. Y., December, 1886, Vol. II, p. 175.

Notes on *Aphis maidis*, root form.

*1886.* Garman, H.—A second contribution to the life-history of the corn plant-louse, *Aphis maidis* Fitch. Miscellaneous Essays on Economic Entomology by the State Entomologist and his Assistants. <Trans. Dept. Agr. Ill. for 1885, Springfield, Vol. XXIII, pp. 46–48.

First record of the occurrence of the oviparous female (October 7), root form, and descriptions of it. Also notes on relation of the root-aphis and ants.

1886. HUNT, THOMAS F.—Partial economic bibliography of Indian corn insects. Miscellaneous Essays on Economic Entomology by the State Entomologist and his Assistants. <Trans. Dept. Agr. Ill., Springfield, Vol. XXIII, pp. 117–118. Separate: Springfield, Ill., 1886.

Gives a bibliography, partially analytical, of *Aphis maidis* (root and aerial forms).

1886. WEBSTER, F. M.—Insects affecting the corn crop. <35th Ann. Rep. Ind. State Bd. Agr. for 1885, Indianapolis, Vol. XXVII, pp. 183–184.

Bibliography of the corn aphis, *Aphis maidis* Fitch (root and aerial forms). Notes and general discussion, including observations on the relation of corn root-aphis and ants.

1887. COMSTOCK, J. H.—Relations of ants and aphids. <Amer. Nat., Philadelphia, Pa., Vol. XXI, p. 382.

Reference to the dependence of the corn root-aphis upon the ant.

1887. FORBES, S. A.—Relations of ants and aphids. <Amer. Nat., Philadelphia, Pa., Vol. XXI, pp. 579–580.

Eggs of *Aphis maidis* (?), root form, found in a nest of *Lasius alienus*. Ants rear young aphides, before ground is planted to corn, upon the roots of *Setaria* and *Polygonum*, transferring them afterwards to corn.

*1887. WEED, C. M.—Insects affecting corn. <Weekly Press, Philadelphia, Pa., September 21, 1887.

*Aphis maidis* (?), root form, hibernates in the egg stage.

1888. COMSTOCK, J. H.—An introduction to entomology. <Ithaca, N. Y., pp. 168–169.

Mentions observations of Forbes with regard to the relations of ants and corn root-aphides.

1888. WEBSTER, F. M.—Report on the season's observations, and especially upon corn insects. <Ann. Rep. U. S. Comm. Agr. for 1887, Washington, D. C., pp. 148–149.

*Rhopalosiphum maidis;* considerable damage done by the root form in Louisiana and Mississippi. Found it on roots of grass (*Setaria glauca*). Three species of ants attend these aphides, viz, *Lasius flavus, Formica schaufussii,* and *F. fusca.* Remedies: Proper fertilizers applied to the soil are a general preventive.

1888. WEBSTER, F. M.—Relation of ants to the corn aphis. <Insect Life, U. S. Dept. Agr., Washington, D. C., Vol. I, pp. 152–153.

Reply to an article by Professor Comstock in American Naturalist. Explains in detail the part played by the ant in the distribution of the corn root-aphis and the care of the eggs of the latter by the ant.

1888. WEED, C. M.—On the occurrence of apterous males among the Aphididæ. <Amer. Nat., Philadelphia, Pa., Vol. XXII, p. 70.

*Aphis maidis,* root form, has apterous males.

1889. ALWOOD, W. B.—The corn plant-louse. <The Southern Planter, Richmond, Va., August, 1889, pp. 116–117.

Article in response to an inquiry from a farmer in that State (Virginia) who had found the aerial and root forms of the corn aphis troubling his crops. Gives life history, and suggests remedy by destruction of fodder and stalks, the plowing up of all stubble in the fall, and the putting of the field to small grain next year.

1889. Forbes, S. A.—Fifteenth Report of the State Entomologist of Illinois for 1885–1886. <Trans. Dept. Agr. Ill. for 1885, Springfield, Vol. XXIII, pp. 5–6. Separate: Springfield, Ill., 1889.

Brief notes on the injuriousness of *Aphis maidis*, and observations made on the winter history of the root form.

1889. Marten, J.—The corn-root aphis. <Prairie Farmer, Chicago, Ill., October 12, 1889, p. 660, 4 figs.

Short general account of *Aphis maidis* (root and aerial forms).

1889. Weed, C. M.—The corn root louse. <Amer. Nat., Philadelphia, Pa., Vol. XXIII, pp. 1105–1106.

Reference to articles on *Aphis maidis* (?), root form, in the Fifteenth and Sixteenth Reports of the State Entomologist of Illinois.

1890. Forbes, S. A.—Sixteenth Report of the State Entomologist of Illinois for 1887 and 1888. <Trans. Dept. Agr. Ill., Springfield, Vol. XXVI, p. XII. Separate: Springfield, Ill., 1890.

Notes on injuries done by corn root-aphis.

1890. Weed, C. M.—Corn insects: An important matter. <Ohio Farmer, Cleveland, Ohio, January 25, 1890, p. 57.

Notes on damage by the corn root-aphis.

1890. Weed, C. M.—Insects affecting corn. <Ohio Agr. Exp. Sta., Columbus, second series, Vol. III, No. 4, pp. 135–136, fig. 20.

Brief notes on the life history of the corn root-aphis.

*1891.*—Forbes, S. A.—Seventeenth Report of the State Entomologist of Illinois for 1889 and 1890. <Trans. Dept. Agr. Ill., Springfield, Vol. XXVIII, pp. 64–70, colored plate "B," figs. 1, 2, 3, 4. Separate: Springfield, Ill., 1891.

*Aphis maidi-radicis*, n. sp. Proposes name for the root form of the corn aphis, and gives a full account of the life history, covering, as points of special interest, time and place of oviposition, stage and place of hibernation, relations of root-aphis to leaf-aphis of corn, other food plants, and the relations of the root-aphis to ants. Economic measures are suggested.

*1891.* Forbes, S. A.—A summary history of the corn root-aphis. <Insect Life, U. S. Dept. Agr., Washington, D. C., Vol. III, pp. 233–238.

Covers the same points in the life history of the corn root-aphis as in the citation above.

* 1891. Osborn, H.—The corn root-aphis. <Orange Judd Farmer, Chicago, Ill., April 25, 1891, p. 260.

Gives suggestions made by Doctor Forbes as to the methods to be used in diminishing the injury by this aphis.

1891. Pearson, J.—Destructiveness of the corn-root plant-louse in Nebraska. <Insect Life, U. S. Dept. Agr., Washington, D. C., Vol. IV, p. 142.

In Nebraska some farmers lost as much as one-third of their crop. He suggests rotation of corn with small grain.

*1891.* Weed, C. M.—Sixth contribution to a knowledge of the life history of certain little-known Aphididæ. <Bul. Ill. State Lab. Nat. Hist., Urbana, Vol. III, art. 12. (Written December, 1887.)

*Aphis maidis* (?), root form. Summary of known life history. Hatching of aphides from eggs in spring. True sexes produced in fall and eggs are laid which are cared for by ants through the winter. Descriptions of the wingless male and the egg.

1891. WEED, C. M.—Insects and Insecticides. <Hanover, N. H., pp. 209–210. fig. 110.

The corn root-aphis (*Aphis maidis* ?). General life history; gives the rotation of crops as the only known successful remedy.

1891. WILLIAMS, T. A.—Host-plant list of North American Aphididæ. <Special Bul. 1, Univ. Nebr., Dept. Ent., Lincoln, pp. 10, 14, 16, 21, 23.

Lists of food plants of *Aphis maidis*, feeding on roots, as dock (*Rumex altissimus*), *Setaria glauca*, *S. viridis*, knotweed (*Polygonum persicaria*), plantain (*Plantago major*), ragweed (*Ambrosia trifida*), and smartweed (*Polygonum* sp.).

1892. BRUNER, L.—Report of Entomologist. <Ann. Rep. Nebr. State Board Agr. for 1891, Lincoln, pp. 300–304, fig. 77.

*Aphis maidi-radicis* Forbes. Gives descriptions of all forms. Quotes the life history from that given by Professor Forbes.

1892. RILEY, C. V., and HOWARD, L. O.—Review of Professor Forbes's Sixth Report. <Insect Life, U. S. Dept. Agr., Washington, D. C., Vol. IV, Nos. 9 and 10, p. 293.

Mentions that it contains a summary history of the corn root-aphis and a colored plate of same.

*1892.* WEBSTER, F. M.—Early published references to some of our injurious insects. <Insect Life, U. S. Dept. Agr., Washington, D. C., Vol. IV, Nos. 7 and 8, p. 264.

Gives references to the original descriptions of *Aphis maidis*, root and aerial forms. Gives reference to a note in American Farmer, Vol. IV, p. 71, May 24, 1822, from Mr. Tho. Emory, of Poplar Grove (State not given), relating to a disease of wheat known as "sedging," who says, "I believe this insect is the same as that known by the name of the root-louse in corn, so frequently found in that plant," etc.

1892. RILEY, C. V., and HOWARD, L. O.—The corn root-aphis. <Insect Life, U. S. Dept. Agr., Washington, D. C., Vol. IV, Nos. 7 and 8, p. 285.

Short review of Doctor Weed's article on the corn root-aphis, published as a bulletin of the Illinois State Laboratory of Natural History.

1893. RILEY, C. V., and HOWARD, L. O.—The corn-root plant-louse. <Insect Life, U. S. Dept. Agr., Washington, D. C., Vol. VI, p. 32.

Crop of corn in Maryland owned by E. P. Thomas was damaged 50 per cent last year by this aphis; also injury this year (June 27, 1893).

*1894.* FORBES, S. A.—Eighteenth Report of the State Entomologist of Illinois. <Trans. Dept. Agr. Ill. for 1893, Springfield, Vol. XXXI, pp. 57, 58–85, Pl. VII, figs. 5, 6, Pl. VIII, figs. 1, 2, 3, 4, 5. Separate: Springfield, Ill., 1894.

The corn root-aphis (*Aphis maidi-radicis* Forbes). Injury to corn and to other plants; life history; relation to the corn leaf-aphis; natural enemies; economic procedure; discusses in full (1) rotation, (2) fertilizers and insecticides, (3) breaking up the ants' nests in fall by plowing, etc., (4) early spring plowing, etc. Descriptions of wingless, winged, and pupa of viviparous female, wingless oviparous female, wingless male, and egg.

1894. OSBORN, H.—Corn insects: Their injuries and how to treat them. <Iowa Agr. Exp. Sta., Des Moines, Iowa, Bul. 24, pp. 994–995, fig. 1.

Mentions *Aphis maidi-radicis* as an important corn insect, although as yet it hardly seems probable that the species has become very much distributed in Iowa.

1894. Sempers, F. W.—Injurious insects and the use of insecticides. <Philadelphia, Pa., p. 157.

Short account of the corn root-aphis, with remedies. "No artificial remedy is known for this pest. In small garden patches kerosene emulsion might be used for drenching about the roots, but treatment with this insecticide has not been regarded as practicable on a large scale."

1895. Comstock, John Henry, and Comstock, Anna Botsford.—Manual for the Study of Insects. <Ithaca, N. Y., p. 158.

Mentions dependence of root-aphis upon ants as given by Forbes.

*1896.* Forbes, S. A.—Insects injurious to the seed and root of Indian corn. <Ill. Agr. Exp. Sta., Urbana, Bul. 44, pp. 237–257, figs. 33–37.

Largely a recapitulation of the account given in the Eighteenth Report of the State Entomologist of Illinois.

1896. Smith, J. B.—Economic entomology. <Philadelphia, Pa., p. 134.

Mentions the corn root-aphis and methods to be used against it.

1896. Hopkins, A. D., and Rumsey, W. E.—Practical entomology. <W. Va. Agr. Exp. Sta., Charleston, Bul. 44, p. 279.

Short and general account of the life history of *Aphis maidi-radicis*. It was found to be exceedingly common and destructive to corn in Jackson, W. Va., in May, 1891. Remedies are given.

*1898. Webster, F. M.—Entomology. <Ohio Farmer, Cleveland, Ohio, September 1, 1898, p. 143.

Notes on *Aphis maidi-radicis*.

1899. King, Geo. B.—China asters infested by a coccid. <Psyche, Cambridge, Mass., Vol. VIII, p. 312.

Reports that *Aphis maidi-radicis* is found on roots of asters in Massachusetts.

1900. Lugger, O.—Bugs injurious to cultivated plants. <Minn. Agr. Exp. Sta., St. Paul, Bul. 69, pp. 184–185, fig. 154½.

Quotes Osborn in regard to the corn root-aphis.

1900. Smith, J. B.—Insects of New Jersey. <Supplement to Twenty-seventh Ann. Rep. State Board Agr. N. J. for 1899, Trenton, p. 104.

Lists *Aphis maidis* Fitch and speaks of it as often causing serious injury to the young plants by its attacks on the roots.

1901. Bruner, L.—Corn-root insects. <Nebraska Farmer, Lincoln, Nebr., February 14, 1901, figs.

General account of the life history of the corn root-aphis, with suggested remedies.

1901. Hunter, W. D.—The Aphididæ of North America. <Ia. Agr. Exp. Sta., Ames, Bul. 60, pp. 98–99.

Lists *Aphis maidi-radicis* from Iowa; gives other States in which it is found; food plants and bibliography of literature.

1901. Sanderson, E. D.—The corn root-louse. <Twelfth Ann. Rep. Del. Agr. Exp. Sta. for 1900, Wilmington, p. 211.

Sweet and sugar corn worse affected than field corn. Aphides common on weeds early in the season and were found on squash roots in June.

1902. Sanderson, E. D.—Insects injurious to staple crops. <New York, N. Y., pp. 134–141, figs. 74–76.

The corn root-louse (*Aphis maidi-radicis* Forbes). A general description of the aphis; distribution; food habits; life history; care by ants; remedies.

1902. WASHBURN, F. L.—Insects notably injurious in 1902. <Seventh Ann. Rep. State Ent. Minn., St. Anthony Park, p. 64, fig. 155. Also as Bul. 77, Minn. Agr. Exp. Sta., November, 1902.

Brief notes on *Aphis maidis* Fitch (root and aerial forms) as occurring in Minnesota; remedies.

*1904. STEDMAN, J. M.—Common corn insects. <Mo. State Board Agr., Bul. 3, No. 11, pp. 11–17.

Notes on the corn root-aphis in Missouri.

*1905.* FORBES, S. A.—Field experiments and observations on insects injurious to corn. <Ill. Agr. Exp. Sta., Urbana, Bul. 104, pp. 102–123.

Discuss experiments made in 1904–1905 to control the corn root-aphis by means of treatment of the soil before planting. Also gives additional notes on the life history.

1905. FORBES, S. A.—Injurious insects of corn. A conference on the corn insects of Illinois, at the Tenth Ann. Meeting of the Ill. Farmers' Institute, at Joliet, Ill. <Springfield, Ill. Plate. Also in Rep. Ill. Farmers' Institute, Springfield, Vol. X, pp. 35–45.

Gives account of the corn root-aphis and experiments made in the past year. Questions and answers. One colored plate of the corn root-aphis and the root-aphis ant.

1905. FORBES, S. A.—The principal insects injurious to the corn plant. <Report Ill. Farmers' Institute, Springfield, Vol. X, pp. 240–251, figs. 17–22.

Injury to corn and to other plants; life history; relation to ants; economic procedure.

1905. KOHLER, A. R.—Insects injurious to corn. <Iowa Agriculturist, Ames, Iowa, Vol. VI, No. 3, pp. 84–85.

Short account of the corn root-aphis.

1905. PETTIT, R. H.—Insects of the garden. <Mich. Agr. Exp. Sta., Agricultural College, Bul. 233, p. 53. Also in Nineteenth Ann. Rep. Mich. Agr. Exp. Sta., Agricultural College, 1906, p. 204.

Mentions *Aphis maidi-radicis* as a corn insect, but that thus far it has not been observed in Michigan.

1905. SYMONS, T. B.—Common injurious and beneficial insects in Maryland. <Md. Agr. Exp. Sta., College Park, Bul. 101, pp. 160–161.

The corn root-aphis. Short notes and remedies.

1906. DAVIS, J. J.—The corn root-louse (*Aphis maidi-radicis* Forbes). <Illinois Agriculturist, Urbana, Vol. X, March, pp. 213–218, 6 figs. Abstract: Wallace's Farmer, Des Moines, Iowa, Vol. XXXI, May 11, 1906, p. 637, 6 figs.

General account of habits, life history, etc., and remedies.

*1906.* FORBES, S. A.—The corn root-aphis and its attendant ant. <U. S. Dept. Agr., Bur. Ent., Washington, D. C., Bul. 60, pp. 29–41.

A complete account of the corn root-aphis. Discusses economic importance, life history, the attendant ant, relation of ant and aphis, injury to corn, natural checks on increase, practical economic measures, and a preventive routine.

1906. KIRKALDY, G. W.—Catalogue of the hemipterous family Aphidæ, with their typical species, together with a list of the species described as new from 1885 to 1895. <Can. Ent., London, Ont., Vol. XXXVIII, p. 13.

Lists *Aphis maidi-radicis* Forbes.

1906. Sanborn, C. E.—Kansas Aphididæ, with catalogue of North American Aphididæ, and with host-plant and plant-host list. Part 2. <Kansas Univ. Sci. Bul., Lawrence, Vol. III, No. 8, p. 258.

Lists food plants of *Aphis maidi-radicis* Forbes as *Amarantus hybridus, Erigeron canadensis, Oxalis stricta, Plantago major, Portulaca oleracea, Rumex crispus, Setaria italica germanica ochloa,* and corn.

1907. Chittenden, F. H.—Insects injurious to vegetables. <New York, pp. 189–190, fig. 121.

Short account of the corn root-aphis, including economic treatment.

*1907.* Forbes, S. A.—The corn root-louse. <Fayette County Democrat, Effingham, Ill., Vol. XLVII, No. 19, March 6, 1907; Bureau County (Ill.) Record, March 6; The Weekly Pantagraph, Bloomington, Ill., Vol. XC, No. 12, March 22. Also in many other Illinois newspapers.

Gives detailed accounts of the new oil-of-lemon treatment, which he has found to be the most effective method of controlling the corn root-aphis.

1907. Stout, J. P.—Control of the corn root-aphis. <Illinois Agriculturist, Urbana, April, pp. 245–247, 4 figs.

Gives methods which have been successfully used to combat the corn root-aphis, including the oil-of-lemon treatment, which Doctor Forbes has proved to be the most practical method of controlling this root-aphis.

*1907.* Webster, F. M.—The corn leaf-aphis and corn root-aphis. <U. S. Dept. Agr., Bur. Ent., Washington, D. C., Cir 86, May 6, 1907, figs. 3, 4.

Gives general description and discusses: Root-aphis and the little brown ant; life history and habits; natural enemies; preventive and remedial measures.

1907. Forbes, S. A.—Insects in relation to health. <Rept. Ill. Farmers' Inst., Springfield, vol. 12, pp. 263–265.

In a few introductory remarks, preceding a lecture on "Insects in relation to health," Doctor Forbes reports on the success of the oil-of-lemon treatment for corn seed to protect it from the attacks of the corn root-aphis. Methods of treating the seed are given.

*1908.* Forbes, S. A.—Experiments with repellents against the corn root-aphis. <Journ. Econ. Ent., Concord, N. H., vol. 1, No. 2, pp. 81–83.

Abstract of a paper read by Doctor Forbes at the 20th annual meeting of the Association of Economic Entomologists. Gives in detail results of field experiments, in 1906, against the corn root-aphis by treatment of the seed with oil of lemon, carbolic acid, formalin, and kerosene.

*1908.* Forbes, S. A.—Experiments with repellents against the corn root-aphis. <Orange Judd Farmer, Chicago, Ill, vol. 44, No. 16, April 15, pp. 501, 504.

Gives results of field experiments, in 1906, against the corn root-aphis by a treatment of the seed with oil of lemon, carbolic acid, formalin, and kerosene. Several farmers who used the oil-of-lemon treatment in 1907 reported injury by the treatment. Mentions that further experiments will be made in Illinois in 1908.

## THE CORN LEAF-APHIS.

(*Aphis maidis* Fitch.)

### GENERAL ACCOUNT.

The corn leaf-aphis was first found injuring corn by Dr. Asa Fitch, and in his Second Report of the Insects of New York (1856) he describes it, and proposes for it the name of *Aphis maidis*, giving an

account of its injuries to corn. Although since that time considerable work has been done on this aphis, we do not yet know how it spends the winter. In 1862 Mr. Benjamin D. Walsh found an aphis living on the roots of corn about Rock Island, Ill., and, although he was doubtful as to its identity, he distinguished it by calling it the root form of *Aphis maidis*. From that time until 1891 these two forms were supposed to be the same species, until Doctor Forbes, who had, since his first knowledge of them, regarded them as probably two distinct species, named the subterranean form *Aphis maidi-radicis* in the Seventeenth Report of the State Entomologist of Illinois.

*Aphis maidis* has always been considered more or less injurious to corn, sorghum, and broom corn, although it seldom becomes seriously so. In some cases, however, it injures the corn ears by sucking the sap from the silk and killing it, thus preventing fertilization of the kernels. Only rarely, however, does it stunt the growth of the plant, at least in Illinois, the reason probably being that in this State the aphis does not commence its attacks upon the plant until the last part of June or the first of July, at which time the plant is strong enough to withstand the drain made upon its sap supply by the aphis. This aphis sometimes does considerable injury to the quality of the brush of broom corn by discoloring it, the discoloration being "due to a bacterial affection following upon the plant-louse punctures" (Forbes).

This aphis has a very wide distribution, being found in all parts of the United States where corn is grown; that is, from Maine to California and Texas. Prof. F. M. Webster has reported finding it on sorghum in Australia, where, he says, it is sometimes quite obnoxious, and in a recent circular he says that "the insect is also known from Japan."

### FOOD PLANTS.

Though the usual food plants are corn, sorghum, and broom corn, this species feeds also on various other plants, as barley, *Setaria glauca*, and *Oxalis*. At Urbana, Ill., September 7, 1906, in an infested cornfield, I found *Aphis maidis* also breeding on *Panicum crus-galli* and *Panicum sanguinale*.

In our insectary, in 1906, plants of *Panicum crus-galli* and *Panicum sanguinale*, which had accidentally grown up in some unused pots, became almost covered with *Aphis maidis*. Numbers of these aphides were placed in a Comstock cage containing the common weeds found around cornfields, namely, *Setaria glauca*, *Panicum crus-galli*, *Polygonum pennsylvanicum*, *Panicum proliferum*, *Panicum sanguinale*, broom corn, sorghum, and corn. When examined two days later (September 10, 1906) the aphides were breeding freely on all plants except corn, which was at that time just sprouting. November 4, aphides were on all plants except *Panicum crus-galli*, *Polygonum*

*pennsylvanicum*, and *Panicum proliferum*, which plants were then dead. December 9, there were a few on the sorghum and corn, these being the only plants alive at that time. When examined about a week later all plants in the cage were dead and no aphides could be found. It might be mentioned that this cage was kept at the outdoor temperature. This aphis shows a decided preference for broom corn over Indian corn and sorghum. Both in the field and in the insectary aphides which had been living on sorghum plants for a number of generations always changed to broom-corn plants when these were placed in the cages.

## LIFE HISTORY.

As stated above, we do not know where and how this aphis passes the winter. In Illinois it first appears in midsummer, the earliest date being June 26, 1906, at which time Mr. E. O. G. Kelly found it quite numerous on broom corn at Mattoon, in central Illinois. We know that it reproduces parthenogenetically from the time of its first appearance in the fields until its disappearance in the fall. In the fall, so far as has yet been observed, these aphides gradually die off as freezing weather comes, leaving neither eggs nor hibernating adults upon or about the corn plants. I did not make any observations in the field in 1906, but in 1905 (a more severe season than 1906) I found living *Aphis maidis* on sorghum as late as October 28, and all found at that date were either winged or the pupæ of winged viviparous females. Numerous experiments have been made by Doctor Forbes and his assistants to determine the manner in which this species hibernates, and whether or not there is a sexual generation in the fall, as is usually the case with aphides. Since these investigations were thorough, it seems possible that the aphides may not spend the winter in the egg stage, at least in central or northern Illinois. There are at least two permissible suppositions as to the winter history of these insects. They may hibernate as adults in the warmer States, or even in southern Illinois, and, as the summer progresses, gradually diffuse themselves to the North with the advance of the season and infest the plants in these northern States. This supposition is plausible, inasmuch as this species has been found in Mississippi on barley in January; but the fact that aphides are probably unable to travel great distances is against it. No work has been done as yet on this line of investigation, and it is possible that if one began his search for this aphis in the far South—even in the southern part of Illinois—he would find it at a much earlier date than it has heretofore been reported, and that he could follow its gradual diffusion northward. The other and more likely theory is that, like many aphides, it has an alternate food plant on which it passes the winter and spring.

I have worked out in the insectary (1906) the summer history as regards the number of generations, rate of multiplication, number of young, etc. *Aphis maidis* was collected by Mr. Kelly June 26, and specimens sent in by him were reared on sorghum and broom corn. From that date until killed by the cold weather in the fall a maximum of 17 generations was obtained. (See Table VII and fig. 33.)

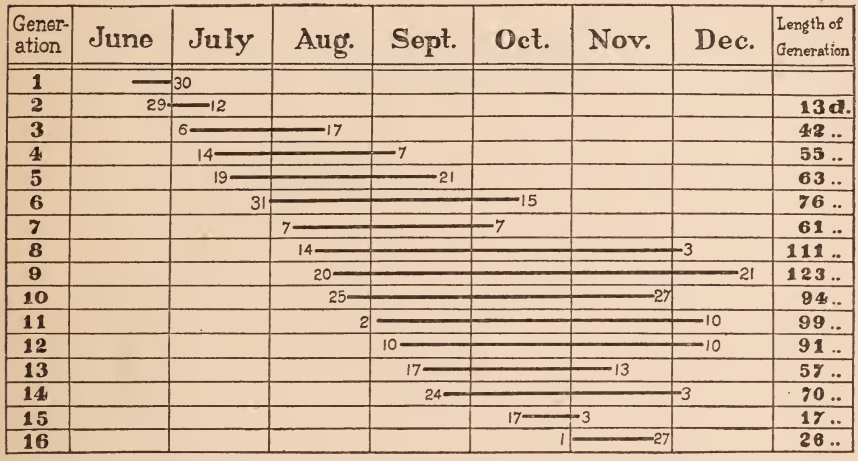


FIG. 33.—Periods and succession of generations in *Aphis maidis*, 1906.

TABLE VII.—*Line of generations of Aphis maidis, June 26–November 22, 1906.*

| Generation in insectary. | Date of birth. | Date of first young. | Age at birth of first young. | Date of last young. | Productive period. | Number of young. | Average young per day of productive period. | Largest number of young in 1 day (at least). | Period after last young. | Date of death or disappearance. | Total length of life. | Food plant used. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1906. | | *Days.* | | *Days.* | | | | *Days.* | | *Days.* | |
| 1 | [a]June 26 | June 28–June 29 | ..... | ..... | ..... | 6 | ..... | ..... | ..... | ..... | ..... | Sorghum. |
| 2 | June 29 | July 6 | 7 | July 12 | 7 | 18 | 2.6— | 3 | 0 | July 12.... | 14 | Do. |
| 3 | July 9-11 | July 15 | 5-6 | Aug. 4 | 20 | 38 | 1.9 | 5 | 13 | Aug. 17 ... | 39 | Broom corn. |
| 4 | July 15 | July 21 | 6 | Aug. 8 | 18 | 44 | 2.4+ | 5 | 11 | Aug. 19 ... | 35 | Do. |
| 5 | July 25 | July 31 | 6 | Aug. 18 | 18 | 35 | 2 — | 3 | 6 | Aug. 24 ... | 30 | Do. |
| 6 | July 31 | Aug. 7 | 7 | Sept. 2 | 26 | 38 | 1.5— | 4 | 0 | Sept. 2.... | 33 | Do. |
| 7 | Aug. 7 | Aug. 13 | 6 | Sept. 6 | 24 | 47 | 1.9+ | 5 | 1 | Sept. 8.... | 31 | Do. |
| 8 | Aug. 13 | Aug. 19 | 6 | Aug. 30 | 12 | 36 | 3 | 4 | 0 | Aug. 30 ... | 18 | Do. |
| 9 | Aug. 19 | Aug. 25. | 5 | Sept. 6 | 12 | 29 | 2.4+ | 4 | 0 | Sept. 7.... | 17 | Do. |
| 10 | Aug. 25 | Sept. 2 | 8 | Sept. 12 | 10 | 17 | 1.7 | 2 | 0 | Sept. 12... | 18 | Do. |
| 11 | Sept. 2 | Sept. 9 | 7 | Oct. 11 | 32 | 52 | 1.6+ | 4 | 4 | Oct. 15.... | 43 | Do. |
| 12 | Sept. 9 | Sept. 16 | 7 | Sept. 23 | 7 | 20 | 2.8+ | 3 | 0 | Sept. 23... | 14 | Do. |
| 13 | Sept. 16 | Sept. 24 | 8 | Oct. 15 | 21 | 33 | 1.5+ | 3 | 0 | Oct. 15.... | 29 | Do. |
| 14 | Sept. 24 | Oct. 4 | 10 | Oct. 4 | 2 | 1 | .5 | ..... | 0 | Oct. 4..... | 11 | Do. |
| 15 | Oct. 4 | Oct. 16 | 12 | Oct. 17 | 2 | 4 | 2 | ..... | ..... | Oct. 17-22. | 14 | Do. |
| 16 | Oct. 16 | Nov. 1 | 15 | Oct. 2 | 1 | 2 | 2 | ..... | ..... | Nov. 3.... | 16 | Do. |
| 17 | [b]Nov. 1 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | |

[a] Collected on broom corn.
[b] Became adult November 22, but disappeared before giving birth to any young.

TABLE VIII.—*Data of individual experiments with Aphis maidis, viviparous generation, 1906.*

| Date of birth. | Date of first young. | Age at birth of first young. | Date of last young. | Productive period. | Number of young. | Average young per day of productive period. | Largest number of young in one day (at least). | Period after last young. | Date of death or disappearance. | Total length of life. | Food plant used. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *Days.* | | *Days.* | | | | *Days.* | | *Days.* | |
| June 28–29 | July 6 | 7–8 | July 12 | 7 | 18 | 2.6 − | 3 | 0 | July 12 | 14 | Sorghum. |
| July 9–10 | July 15 | 5–6 | Aug. 4 | 20 | 38 | 1.9 | 5 | 13 | Aug. 17 | 39 | Broom corn. |
| July 6 | July 14 | 8 | Aug. 6 | 23 | 33 | 1.4 + | 3 | 5 | Aug. 11 | 36 | Sorghum. |
| July 9 | do | 5 | July 30 | 16 | 22 | 1.3 + | 2 | 11 | do | 32 | Do. |
| July 14 | July 20 | 6 | Aug. 3 | 13 | 38 | 2.9 + | 6 | 0 | Aug. 3 | 19 | Broom corn. |
| July 15 | July 21 | 6 | Aug. 8 | 18 | 44 | 2.4 + | 5 | 11 | Aug. 19 | 35 | Do. |
| July 27 | Aug. 1 | 5 | Aug. 22 | 21 | 49 | 2.4 − | 5 | 6 | Aug. 28 | 32 | Do. |
| July 25 | July 31 | 6 | Aug. 18 | 18 | 35 | 2 − | 3 | 6 | Aug. 24 | 30 | Do. |
| July 31 | Aug. 7 | 7 | Sept. 2 | 26 | 38 | 1.5 − | 4 | 0 | Sept. 2 | 45 | Do. |
| August 1 | do | 6 | Aug. 11 | 5 | 13 | 2.6 | 4 | 0 | Aug. 11–13 | [a] 11 | Do. |
| August 7 | Aug. 13 | 6 | Sept. 6 | 24 | 47 | 1.9 + | 5 | 1 | Sept. 8 | 31 | Do. |
| Do | Aug. 14 | 7 | Aug. 20 | 7 | 26 | 3.7 + | 6 | 0 | Aug. 20 | [a] 14 | Do. |
| August 10 | Aug. 16 | 6 | Sept. 13 | 28 | 49 | 1.7 + | 4 | 8 | Sept. 21 | 42 | Do. |
| August 13 | Aug. 19 | 6 | Aug. 30 | 12 | 36 | 3 | 4 | 0 | Aug. 30 | 18 | Do. |
| August 14 | Aug. 20 | 6 | Sept. 16 | 27 | 47 | 1.7 | 6 | 10 | Sept. 26 | 43 | Do. |
| August 17 | Aug. 22 | 5 | do | 25 | 64 | 2.5 + | 4 | 19 | Oct. 6 | 49 | Do. |
| August 20 | Aug. 25 | 5 | Sept. 6 | 12 | 29 | 2.4 + | 4 | 0 | Sept. 7 | 17 | Do. |
| Do | Aug. 27 | 7 | Sept. 23 | 27 | 65 | 2.4 + | 5 | 7 | Sept. 30 | 41 | Do. |
| August 3–4 | Aug. 10 | 6–7 | Sept. 2 | 23 | 32 | 1.3 + | 3 | 5 | Sept. 7 | 34 | Do. |
| August 22 | Aug. 29 | 7 | Sept. 9 | 11 | 14 | 1.2 + | 3 | 0 | Sept. 9 | 18 | Do. |
| August 25 | Sept. 2 | 8 | Sept. 12 | 10 | 17 | 1.7 | 2 | 0 | Sept. 12 | 18 | Do. |
| August 27 | Sept. 7 | 11 | Sept. 8 | 2 | 5 | 2.5 | ..... | 0 | Sept. 8 | 13 | Do. |
| September 7 | Sept. 14 | 7 | Sept. 26 | 12 | 28 | 2.3 + | 4 | 0 | Sept. 26 | 19 | Do. |
| September 2 | Sept. 9 | 7 | Sept. 11 | 32 | 52 | 1.6 + | 4 | 4 | Oct. 15 | 43 | Do. |
| August 31–September 2 | Sept. 8 | 6–8 | Sept. 18 | 10 | 23 | 2.3 | 3 | 0 | Sept. 18 | 16–18 | Do. |
| September 7 | Sept. 14 | 7 | Sept. 23 | 9 | 26 | 2.8 + | ..... | 0 | Sept. 23 | 16 | Do. |
| September 9 | Sept. 16 | 7 | do | 7 | 20 | 2.8 + | 3 | 0 | do | 14 | Do. |
| Do | Sept. 15 | 6 | Oct. 5 | 20 | 38 | 1.9 + | 5 | 10 | Oct. 15 | 36 | Do. |
| September 14 | Sept. 21 | 7 | Nov. 8 | 48 | 59 | 1.2 | 4 | ..... | Nov. 8–13 | 55 | Do. |
| September 16 | Sept. 24 | 8 | Oct. 15 | 21 | 33 | 1.5 + | 3 | 0 | Oct. 15 | 29 | Do. |
| September 24 | Oct. 4 | 10 | Oct. 4 | [a] 2 | (a) | ..... | ..... | ..... | Oct. 5 | [a] 11 | Do. |
| September 21 | Sept. 28 | 7 | Sept. 30 | [a] 3 | 7 | 2.3 + | ..... | ..... | Sept. 30 | [a] 10 | Do. |
| October 4 | Oct. 16 | 12 | Oct. 17 | [a] 2 | [a] 4 | 2 | ..... | ..... | Oct. 17–22 | 14 | Do. |
| September 23 | Oct. 2 | 9 | Oct. 28 | 26 | [a] 35 | 1.3 + | 4 | 37–44 | Dec. 3–10 | 72 | Do. |
| Do | do | 9 | Nov. 13 | 42 | 31 | [a] 0.7 + | 4 | 14 | Nov. 27 | 65 | Do. |
| October 1 | Oct. 11 | 10 | Oct. 12 | [a] 1 | [a] 1 | [a] 1 + | ..... | ..... | Oct. 11–13 | [a] 11 | Do. |
| October 17 | Nov. 1 | 15 | Oct. 2 | [a] 1 | [a] 2 | [a] 2 | ..... | ..... | Nov. 3 | 16 | Do. |
| October 20 | Oct. 28–Nov. 1 | 8–12 | Nov. 27 | 26–30 | 14+ | (a) | ..... | 6 | Dec. 3–10 | 44 | Do. |
| October 25 | Nov. 18 | 24 | Nov. 22 | [a] 4 | [a] 3 | [a] 0.7 + | ..... | ..... | Nov. 22 | 28 | Do. |
| November 1 | Nov. 22–27 | 22–27 | Dec. 3–10 | (a) | (a) | (a) | ..... | ..... | Dec. 10 | 40 | Do. |
| Average | | 8.15 | | 19.0+ | 33.5 | 2.04+ | | | | 31.6+ | |

[a] Not counted in making averages.

Although no exact figures can be given as to the minimum number of generations (breeding always from the last born of each generation), still, from my experiments, it may be definitely said that there were not more than 9 generations after June 26. The aphides were kept in the unheated insectary greenhouse, and thus the temperature was approximately the same as that out of doors. The last date recorded for living aphides was December 21. The immature stage covered from 5 to 24 days, varying with the season; thus, in the warmer parts of the year, from the last of June until the middle of September, the average for 30 experiments was 6.6 days, while from the middle of September until the 1st of November for 10 experiments the average was 12.8 days. The average for the entire 40 experiments was 8.1+ days. (Table VIII.)

The length of the period for producing young varied up to 48 days, with an average, for the entire series of experiments, of 19 days. The mother usually lived a few days after the birth of her last young. The entire length of life averaged 31.6+ days. The average number of young produced by a single aphis, in the 33 experiments of which record was kept, was 33.5+, while the largest number was 65. Individual aphides in some cases produced as many as 6 or 8 young per day, but the usual number was 2. The number of molts is invariably 4. Table IX gives the records of a few individuals, showing the number of molts and the time between each molt.

TABLE IX.—*Periods of molts of Aphis maidis, viviparous generation, 1906–7.*

| Date of birth. | Age at first molt. | Age at second molt. | Age at third molt. | Age at fourth molt. | Age at birth of first young. |
|---|---|---|---|---|---|
| | *Days.* | *Days.* | *Days.* | *Days.* | *Days.* |
| July 23, 1905 | 2 | 3 | 5 | 8 | 9 |
| Do | 2 | 4 | 5 | 6 | 7 |
| July 24, 1905 | 1 | 3 | 5 | 7 | 7 |
| July 27, 1905 | 2 | 3 | 4 | 6 | 7 |
| August 4, 1905 | 1 | 3 | 4 | 6 | 6 |
| August 5, 1906 | 1 | 2 | 4 | 6 | 6 |
| August 14, 1906 | 2 | 3 | 4 | 6 | 6 |

## DESCRIPTIONS.

### *Aphis maidis* Fitch.

#### VIVIPAROUS GENERATION.

*Before first molt and less than 1 hour old.*—General color light pea-green. Eyes red. Antennæ transparent, only 4 distinct segments, or 5 if the filament be counted, the third having a slight contriction, which is the beginning of a division of that segment. Legs transparent. Cornicles vasiform. Measurements: Length of body, 0.545 mm.; width, 0.236 mm.

*After first molt and 24–48 hours old.*—General color between pea-green and chromium-green. Eyes red. Antennæ as in the earlier

stages, but not transparent, while the constriction of the third segment is more distinct, and there is a sensorium at the apical end of the third segment. Fore part of head darker than body color. Legs paler than body color, except parts of the femur and tarsus, which are darker; the tip of the abdomen also is darker. Cornicles longer and more distinct than before first molt. Measurements: Length of body, 0.927 mm.; width, 0.363 mm.; antennæ, 0.325 mm.

*After second molt and 48–72 hours old.*—General color chromium-green, the sides being slightly darker. Head and first thoracic segment bottle-green. Eyes dark red. Antennæ pale green, with black tips. What was spoken of in the earlier stages as the third segment is now divided into two distinct segments; otherwise, except as to size, the antennæ are the same as in the earlier stages. Tips of legs black. Tip of abdomen dark chromium-green. The black cornicles are surrounded at their bases by dark green patches. Measurements: Length of body, 1.090 mm.; width, 0.454 mm.; antennæ, 0.342 mm.

*After third molt and 96–120 hours old.*—General color chromium-green. Head and first thoracic segment darker green. Eyes dark red. First and last segments of the antennæ black. As yet only 5 distinct segments, or 6 if the filament be counted. Tarsi black; femora of the posterior pairs of legs partly black. Tip of abdomen dark green; penultimate segment with a stripe of dark green nearly covering the entire segment. Cornicles black, with dark-green basal spots. Measurements: Length of body, 1.254 mm.; width, 0.527 mm.; antennæ, I, 0.044 mm.; II, 0.037 mm.; III, 0.132 mm.; IV, 0.061 mm.; V, basal, 0.057 mm.; filament, 0.117 mm.; total, 0.448 mm.

*Adult wingless female.*—Head black. Antennæ black, excepting third segment. Eyes very dark reddish brown. Beak dark, its apex black, shading to brown. General color of body blue-green. Fore segments and tip of abdomen very dark green. Legs black, excepting middle portion of femur. Cornicles black, slightly incrassate at the base and with a dark-green basal patch. The adult gradually becomes darker in color as it grows older, and when it has about finished with the production of young it is almost black in color, having a slightly greenish and brownish tint. Measurements (from alcoholic specimens collected on broom corn at Mattoon, Ill., July 6, 1906): Length of body, 2.363 mm.; width, 1.091 mm.; antennæ, I, 0.067 mm.; II, 0.054 mm.; III, 0.193 mm.; IV, 0.115 mm.; V, 0.111 mm.; VI, basal, 0.077 mm.; filament, 0.176 mm.; total, 0.793 mm.; cornicles, 0.203 mm.; style, 0.101 mm. The specimens reared in the insectary were somewhat smaller than the above.

*Adult winged female.*—Head black. Antennæ black, and with 6 segments, or 7 if the filament be counted. Antennal sensoria circular, 16 to 20 on III, 4 on IV, several at apical end of V, and also at apical end of the basal part of VI. Eyes dark brown or

black. Thorax and legs black. Abdomen pale bluish green. Three black spots on each side of the body and anterior to the cornicles, and a black basal spot surrounding each cornicle. Posterior to the cornicles are 2 black spots, one on each side, and also 3 more or less distinct transverse black bands. Cornicles black, slightly incrassate at middle, dilated at apex. Distal half of dorsally curved style black, and the remainder margined with black to the base. Measurements (alcoholic specimens): Length of body, 1.709 mm.; width, 0.618 mm.; wing expanse, 5.786 mm.; antennæ, I, 0.065 mm.; II, 0.057 mm.; III, 0.293 mm.; IV, 0.154 mm.; V, 0.154 mm.; VI, basal, 0.106 mm.; filament, 0.228 mm.; total, 1.057 mm.; cornicles, 0.130 mm.; style, 0.081 mm.

*Pupa of winged female.*—Body pale green. Head dark brown, with a more or less distinct median white line. Antennæ darker at either end. Antennæ with a sensorium at the end of V, and 2 or more at the distal end of the basal portion of VI. Wing-pads, tip of abdomen, and cornicles black. Legs dark, almost black. Cornicles noticeably incrassate at middle and slightly dilated at the tip. Measurements (alcoholic specimens): Length of body, 1.999 mm.; width, 0.799 mm.; antennæ, I, 0.067 mm.; II, 0.057 mm.; III, 0.183 mm.; IV, 0.125 mm.; V, 0.098 mm.; VI, basal, 0.084 mm.; filament, 0.159 mm.; total, 0.773 mm.; cornicles, 0.155 mm.

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*Aphis maidis* observed in conspicuous numbers on sorghum plants growing on the farm of the Agricultural College of South Australia. It is sometimes so abundant on plants as to render the latter obnoxious to stock.

1890. Forbes, S. A.—Sixteenth Report of the State Entomologist of Illinois, for 1887 and 1888. <Trans. Dept. Agr. Ill., Springfield, Vol. XXVI, p. XII. Separate: Springfield, Ill., 1890.

Notes scarcity of aerial form of the corn aphis the past two years.

1890. Kent, G. H.—Notes of the season from Mississippi. (Roxie, Miss.) <Insect Life, U. S. Dept. Agr., Washington, D. C., Vol. II, No. 9, p. 283.

The corn aphis was observed in large groups on corn and sorghum plants.

1891. Forbes, S. A.—Seventeenth Report of the State Entomologist of Illinois. <Trans. Dept. Agr. Ill., Springfield, Vol. XXVIII. Separate: Springfield, Ill., 1891.

Colored plates of pupa, winged, and wingless forms of *Aphis maidis* Fitch.

1891. McCarthy, Gerald.—Some injurious insects <N. C. Agr. Exp. Sta., Raleigh, Bul. 78, p. 18.

Brief notes on the corn plant-louse.

1891. Weed, C. M.—Insects and insecticides. <Hanover, N. H., pp. 216–217, fig. 10.

Brief account of known life history of *Aphis maidis*, with insects parasitic upon it. Remedies.

1891. Williams, T. A.—Host plant list of North American Aphididæ. <Univ. Nebr. Dept. Ent., Lincoln, Spec. Bul. 1, pp. 9, 19, 23.

Lists the food plants of *Aphis maidis* Fitch as corn, cultivated *Oxalis*, and cultivated sorghum.

1892. Bruner, L.—Report of the Entomologist. <Ann. Rep. Nebr. State Board Agr. for 1891, Lincoln, pp. 299–300, fig. 75.

*Aphis maidis* Fitch attacks corn in overwhelming numbers at times. Gives characters distinguishing it from the root-aphis (*Aphis maidi-radicis*).

1892. Osborn, Herbert.—Catalogue of the Hemiptera of Iowa. <Proc. Ia. Acad. Sci., Des Moines, Vol. I, pt. 2, p. 129.

Lists *Aphis maidis* Fitch and mentions that it has been reported to him as infesting corn in Iowa.

1892. Webster, F. M.—Early published references to some of our injurious insects. <Insect Life, U. S. Dept. Agr., Washington, D. C., Vol. IV, Nos. 7 and 8, p. 264.

Gives references to the original descriptions of *Aphis maidis*, root and aerial forms.

1893. Osborn, H., and Sirrine, F. A.—Notes on Aphididæ. <Proc. Iowa Acad. Sci. for 1892, Des Moines, Vol. I, pt. 3, p. 98.

*Aphis maidis* Fitch, abundant on corn, broom corn, and sorghum in Iowa.

*1894.* Forbes, S. A.—Eighteenth Report of the State Entomologist of Illinois. <Trans. Dept. Agr. Ill. for 1893, Springfield, Vol. XXXI, pp. 69, 70, 73, 74, 82. Separate: Springfield, Ill., 1894.

*Aphis maidis* Fitch. Distinguishes between this and the corn root-aphis; disappearance in the fall; earliest appearance (July 23, 1883); relation to the corn root-aphis; transferring to roots of plants.

1894. Osborn, H.—Corn insects, their injuries, and how to treat them. <Iowa Agr. Exp. Sta., Des Moines, Bul. 24, pp. 991–1005, fig. 9.

Brief notes on the corn leaf-aphis, with suggestions as to remedies.

1895. Cowen, J. H.—A preliminary list of the Hemiptera of Colorado. <Colo. Agr. Exp. Sta., Fort Collins, Bul. 31, Tech. Ser. 1, p. 120.

*Aphis maidis* Fitch. Collected at Fort Collins, Colo., September 14, on maize, and at Hotchkiss, Colo., July 27.

1895. Weed, H. E.—Insects injurious to corn. <Miss. Agr. Exp. Sta., Agricultural College, Bul. 36, p. 158.

Mentions that *Aphis maidis* can generally be found in the cornfields, though it rarely occurs in numbers sufficient to cause extensive damage.

1896. Hopkins, A. D., and Rumsey, W. E.—Practical entomology. <W. Va. Agr. Exp. Sta., Charleston, Bul. 44, pp. 281, 308–309.

Mention of the leaf-aphis, and remedial measures.

1900. Harvey, F. L.—Notes on the insects of the year 1899. <Sixteenth Ann. Rep. Maine Agr. Exp. Sta., Augusta, p. 30.

The corn aphis (*Aphis maidis*) was abundant on sweet corn in some parts of the State.

1900. Lugger, O.—Bugs injurious to cultivated plants. <Minn. Agr. Exp. Sta., St. Paul, Bul. 69, December, 1900, p. 184, fig. 154.

Mentions the corn leaf-aphis as infesting the upper parts of corn plants, with notes on the relations of the ants and root aphides. (Quotes Comstock.)

1901. Hunter, W. D.—The Aphididæ of North America. <Iowa Agr. Exp. Sta., Ames, Bul. 60, September, 1901, p. 98.

Lists *Aphis maidis* Fitch from Iowa; gives bibliography; States in which it has been found; food plants.

1902. Washburn, F. L.—Insects notably injurious in 1902. <Minn. Agr. Exp. Sta., St. Anthony Park, Bul. 77, p. 64, fig. 155. Also as Seventh Ann. Rep. State Ent. Minn.

Brief notes on *Aphis maidis* Fitch (root and aerial forms) as occurring in Minnesota; remedies suggested.

1903. Clarke, W. T.—A list of California Aphididæ. <Can. Ent., London, Ont., Vol. XXXV, p. 25.

Lists *Aphis maidis* from Berkeley and Watsonville, Cal., on corn and sorghum.

1904. Sanborn, C. E.—Kansas Aphididæ, with a catalogue of North American Aphididæ, and with host-plant and plant-host list. <Kans. Univ. Sci. Bul., Lawrence (pt. 1), Vol. III, No. 1, July, 1904, p. 58, fig. 66; (pt. 2) Vol. I, No. 8, April, 1906, p. 258.

Description of winged viviparous female of *Aphis maidis*. Gives food plants as *Setaria glauca, Sorghum halepense,* and *Zea mays.*

1904. SANDERSON, E. D.—Insects of 1903 in Texas. <U. S. Dept. Agr., Div. Ent., Washington, D. C., Bul. 46, p. 93.

*Aphis maidis* received upon barley from Texas, which it had damaged in January and May. In August it becomes abundant on corn, and later on sorghum, and it sometimes does considerable damage.

*1905.* FORBES, S. A.—Twenty-third Report of the State Entomologist of Illinois. <Chicago, pp. 123–133, figs. 115, 117.

The corn leaf-aphis (*Aphis maidis* Fitch). General descriptions of this aphis and its effects on plants. Reported as a corn insect from New York to Texas, Minnesota, and California. Gives in detail field observations and insectary experiments made to determine the winter history, alternate food plants, if any, etc., of the leaf aphis.

1905. PETTIT, R. H.—Insects of the garden. <Mich. Agr. Exp. Sta., Agricultural College, Bul. 233, December, p. 55. Also Nineteenth Ann. Rep. Mich. Exp. Sta., 1906, p. 206.

Mentions *Aphis maidis* as being sometimes injurious to sweet corn in Michigan.

*1907.* WEBSTER, F. M.—The corn leaf-aphis and corn root-aphis. <U. S. Dept. Agr., Bur. Ent., Washington, D. C., Cir. 86, pp. 1–3, May 6, figs 1, 2.

Short review of the history; appearance and habits; field experiments. Reports the occurrence of the leaf-aphis in Japan.

## THE SORGHUM APHIS.

(*Sipha* [*Chaitophorus*] *flava* Forbes.)

The sorghum aphis was first described by Dr. S. A. Forbes in 1883, in the Thirteenth Report of the State Entomologist of Illinois. Doctor Forbes has further mentioned it in several of his reports as State entomologist, but so far as I know nothing else has been written about it.

### LIFE HISTORY.

The life history was, until 1905, unknown, but during that year I made some studies upon this insect and found, among other things, that it passed the winter in the egg stage. In 1906 this aphis was first collected June 28 at Mattoon, Ill., by Mr. E. O. G. Kelly, on sorghum and *Panicum crus-galli*, and the life history from that date until the egg stage in the fall was obtained. Eggs thus obtained were carried through the winter and young hatching from them were reared. The generations were continued during the entire summer until the egg stage in the fall. During my absences in the summer of 1907 the experiments were carried on by Messrs. M. C. Tanquary and E. L. Dillon. June 28 is not the earliest at which this aphis has been collected in the field, as Doctor Forbes has found it on grass as early as May 7. I found 4 young aphides on timothy May 23, 1907, and these were bred on grass. They became winged adults as follows: One on May 30, 2 on June 2, and 1 on June 4. Inasmuch as I found these young aphides separately, and as no mother aphis was found after a careful search, I had supposed them to be stem-mothers, but, so far as I am able to learn, no record of stem-mothers

being winged has ever been made. The eggs began to hatch in the insectary March 16 (1907), and it is probable that in the field the hatching period is chiefly the month of April.

Sorghum and broom corn are the usual plants infested by this species, and upon these it is sometimes abundant and destructive. Doctor Forbes has reported it from sorghum, broom corn, Indian corn, *Setaria*, *Panicum*, and wheat. Mr. Kelly first reported its occurrence on *Panicum crus-galli*, and in 1906 I reared it through a number of generations on *Panicum sanguinale*, and collected it in the field from blue grass, oats, and timothy. Mr. Paul Hayhurst, of the Bureau of Entomology, U. S. Department of Agriculture, wrote me of finding it on *Setaria glauca*. Thus, so far as known, *Sipha flava* feeds only on plants of the grass family (Gramineæ). In Europe there are at present 8 or 9 known species of the genus *Sipha*, and, according to Del Guercio,[a] all, with the exception of one species, *Sipha bignonæ* Macch., feed only upon the grasses of the families Gramineæ and Juncaceæ. *Sipha bignonæ* is probably not a typical *Sipha*, and it was originally doubtfully placed under the genus *Lachnus* by Macchiati.[b] In America two species (*S. rubifolii* and *S. flava*) have been placed under the genus *Sipha*. *S. rubifolii* is found only on blackberry (*Rubus*), but this species probably belongs to an undescribed genus, and undoubtedly does not properly belong under the genus *Sipha* of Passerini.

Heretofore this aphis has never been positively reported outside of Illinois, but this year (1907) Mr. Hayhurst sent me specimens from Minnesota, Virginia, and Oklahoma, and wrote me that he found it also in New York, West Virginia, and Texas. It seems likely, therefore, that it is distributed over the United States, more or less generally, east of the Mississippi River. It will probably be found to be more generally distributed in the South, because all of the known facts regarding the distribution of this species, as well as of the European species of *Sipha*, indicate that they are probably of subtropical origin.

Young hatching from eggs March 18 were reared to adults and successive generations obtained. In one case the *first young of the first young* was taken all the way through the series, 16 generations being obtained. (Table X.)

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[a] Guercio, G. Del.—Contribuzione alla Conoscenza della Sipha Pass. ed alla loro posizione nella Famiglia degli Afidi. <Redia, Firenze, Italy, Vol. II (1904), pp. 127–153.

[b] Macchiati, Luigi.—Fauna e flora degli Afidi di Calabria. <Bul. Soc. Ent. Ital., Vol. XV (1883), p. 262.

TABLE X.—*Line of generations of Sipha flava from egg to oviparous generation, 1907.*

| Generation (from egg). | Date of birth. | Date of first young. | Age at birth of first young. | Last young. | Productive period. | Number of young. | Average young per day of productive period. | Largest number of young in one day. | Life after last young. | Date of death or disappearance. | Total length of life. | Plant used. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | *Days.* | | *Days.* | | | | *Days.* | | *Days.* | |
| 1 | Mar. 18 | Apr. 15 | 28 | June 6 | 52 | 48 | 0.9+ | 4 | 12 | June 19 | 92 | Sorghum. |
| 2 | Apr. 15 | May 16 | 31 | June 24 | 39 | 81 | 2.0+ | 5 | 6 | June 30 | 76 | Broom corn. |
| 3 | May 16 | May 29 | 13 | June 22 | 24 | 73 | 3.0+ | 6 | 8 | June 30 | 45 | Do. |
| 4 | May 29 | June 11 | 13 | July 9 | 28 | 80 | 2.8+ | 7 | 9 | July 18 | 50 | Do. |
| 5 | June 11 | June 21 | 10 | July 11 | 20 | 80 | 4 | 7 | 10 | July 21 | 40 | Do. |
| 6 | June 22 | July 1 | 9 | Aug. 12 | 42 | 56 | 1.3+ | 5 | 0 | Aug. 12 | 51 | Do. |
| 7 | July 1 | July 8 | 7 | July 19 | 11 | 37 | 3.3+ | 4 | 0 | July 19 | 18 | Do. |
| 8 | July 8 | July 16 | 8 | Aug. 16 | 31 | 63 | 2.0+ | 5 | 17 | Sept. 2 | 56 | Do. |
| 9 | July 16 | July 24 | 8 | Aug. 20 | 27 | 57 | 2.1+ | 5 | 3 | Aug. 23 | 38 | Do. |
| 10 | July 24 | Aug. 5 | 12 | Sept. 8 | 34 | 69 | 2.0+ | 6 | 4 | Sept. 12 | 50 | Do. |
| 11 | Aug. 5 | Aug. 13 | 8 | Sept. 16 | 34 | 81 | 2.3+ | 6 | 15 | Oct. 1 | 57 | Do. |
| 12 | Aug. 18 | Aug. 28 | 10 | Sept. 20 | 23 | 69 | 3 | 6 | 0 | Sept. 20 | 33 | Do. |
| 13 | Aug. 28 | Sept. 6 | 9 | Oct. 7 | 31 | 74 | 2.3+ | 7 | 23 | Nov. 1 | 63 | Do. |
| 14 | Sept. 6 | Sept 17 | 11 | Oct. 16 | 29 | 55 | 1.9— | 5 | 47 | Dec. 2 | 87 | Do. |
| 15 | Sept. 17 | Oct. 2 | 15 | Oct. 22 | 20 | 17 | 0.8+ | 5 | 2 | Oct. 24 | 37 | Do. |
| [a]16 | Oct. 2 | | | | | | | | | | | |

[a] Sexual generation.

On the other hand, beginning with the last to be borne by the aphis which had hatched March 18, and following down the series of the last born of each generation, there were but 7 generations in all. From this it follows that the mean number of complete generations

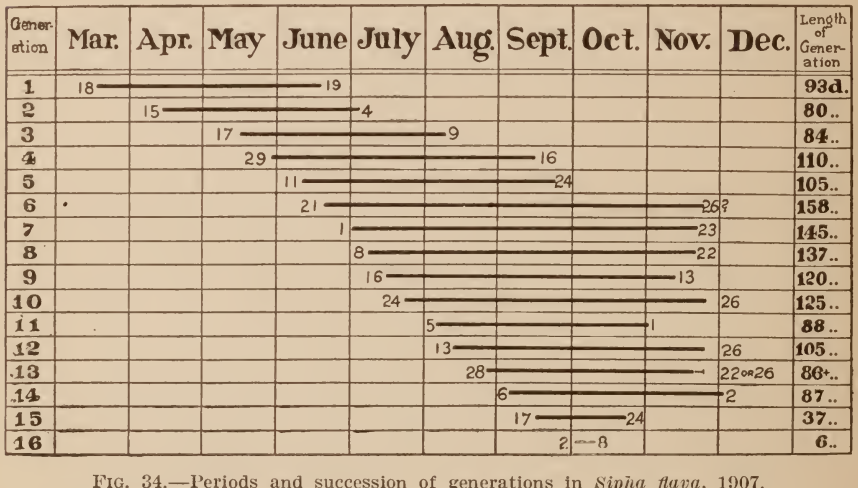


FIG. 34.—Periods and succession of generations in *Sipha flava*, 1907.

for the year is 11½. The first generation lasted for 93 days, from March 18 to June 19, the second extended over a period of 80 days, the third 84 days, and the fourth 110 days. The sixth generation was the longest-lived, continuing for 158 days, the period of the latest generations diminishing gradually. (See fig. 34.) As in the case of *Aphis maidi-radicis*, if the time during which eggs are probably hatching in the field is taken into consideration, it will be

seen that each of the generations might occur in the field much longer than these artificial experiments would indicate.

On April 15 individuals of the first 2 generations coexisted in the insectary; on May 15, the first 3 generations; on June 15, the first 4 generations; on July 1, 6 generations, from the second to the seventh, inclusive; on August 1, 8 generations, from the third to the tenth; on September 1, 10 generations, from the fourth to the thirteenth, and between September 6 and October 8 there were 11 generations in existence, this being the largest number of generations in existence at any one time. From that date on, the number of generations in existence at any one time rapidly diminished until December 2, at which time all of the aphides were dead. (See fig. 34.)

The vivaria used in rearing these aphides were simple, each consisting of a pot of earth containing a young sorghum plant, over which was placed a lamp chimney closed at the top with a fine-meshed cloth. Individuals were transferred from one plant to another by means of a soft camel's-hair brush, and these would usually remain in the same place, even though the leaf became wilted or dying, and thus it was an easy matter to keep track of them and to obtain the numbers of young from day to day. Likewise, in the field this species migrates from one part of the plant to another only to a slight extent. The individuals are usually found on the lower surface of the older and lower leaves, in groups, and the young are almost always found feeding on the leaf around the mother aphis. Another peculiarity of this species is that it is not attended by ants, as are most of the aphides found in the field.

### VIVIPAROUS GENERATION.

All the following data were obtained in 1906 and 1907, unless otherwise stated. The length of time between the birth of an aphis and that of its first young was between 7 and 31 days, and the average for 79 experiments was 13.3 days.

TABLE XI.—*Data of individual experiments on Sipha flava, viviparous generation, 1906–7.*

| Date of birth. | Date of first young. | Age at birth of first young. | Last young. | Productive period. | Number of young. | Average young per day of productive period. | Length of life after last young. | Total length of life. |
|---|---|---|---|---|---|---|---|---|
| 1906. | 1906. | *Days.* | 1906. | *Days.* | | | *Days.* | *Days.* |
| July 1 | July 12 | 11 | July 18 | 6 | 14 | 2.3+ | 0 | 17 |
| July 9–10 | July 19 | 9–10 | July 25 | 6 | 15 | 2.5 | 0 | 15–16 |
| July 12–15 | July 21 | 8–9 | ...do | 4 | 9 | 2.2+ | 0 | 12–13 |
| July 18 | July 27 | 9 | Aug. 16 | 20 | 49 | 2.5— | 2 | 29 |
| July 19 | ...do | 8 | Aug. 4 | 8 | 28 | 3.5 | 0 | 16 |
| July 21 | July 31 | 10 | Aug. 24 | 24 | 68 | 2.8+ | 1 | 34 |
| July 27 | Aug. 4 | 8 | Aug. 26 | 22 | 65 | 2.9+ | 13 | 43 |
| Do | ...do | 8 | Aug. 28 | 24 | 65 | 2.7+ | 27 | 59 |
| July 31 | Aug. 8 | 8 | Aug. 30 | 22 | 59 | 2.7+ | 2 | 32 |
| August 4 | Aug. 13 | 9 | ...do | 27 | 80 | 3 — | 10 | 46 |

TABLE XI.—*Data of individual experiments on Sipha flava, viviparous generation, 1906–7*—Continued.

| Date of birth. | Date of first young. | Age at birth of first young. | Last young. | Productive period. | Number of young. | Average young per day of productive period. | Length of life after last young. | Total length of life. |
|---|---|---|---|---|---|---|---|---|
| 1906. | 1906. | *Days.* | 1906. | *Days.* | | | *Days.* | *Days.* |
| August 6 | Aug. 15 | 9 | Sept. 9 | 25 | 73 | 2.9+ | 13 | 47 |
| August 8 | Aug. 16 | 8 | Sept. 16 | 31 | 77 | 2.5+ | 14 | 53 |
| August 13 | Aug. 21 | 8 | Sept. 13 | 23 | 78 | 3.3+ | 0 | 31 |
| August 15 | Aug. 23 | 8 | Sept. 20 | 28 | 89 | 3.1+ | 8 | 44 |
| August 16 | Aug. 24 | 8 | Sept. 13 | 20 | 49 | 2.5— | 0 | 28 |
| August 14–16 | Aug. 22 | 6–8 | Sept. 11 | 20 | 60 | 3 | 14 | 42 |
| August 21 | Aug. 30 | 9 | Sept. 23 | 24 | 83 | 3.4+ | 21 | 54 |
| August 22 | Sept. 2 | 11 | Oct. 4 | 32 | 83 | 2.6— | 15 | 58 |
| August 23 | Sept. 1 | 9 | Sept. 28 | 27 | 79 | 2.9+ | 27 | 63 |
| August 24 | Sept. 4 | 10 | Oct. 3 | 29 | 67 | 2.3+ | 11 | 50 |
| August 30 | Sept. 9 | 10 | Oct. 14 | 35 | 63 | 1.8 | 31 | 76 |
| September 2 | Sept. 10 | 8 | Oct. 6 | 26 | 75 | 2.8 | 27 | 61 |
| Do | Sept. 11 | 9 | Sept. 30 | 19 | 58 | 3 + | 1 | 29 |
| September 6 | Sept. 14 | 8 | Oct. 7 | 23 | 69 | 3 | 13 | 44 |
| September 9 | Sept. 18 | 9 | Nov. 8 | 51 | 58 | 1 + | 38 | 98 |
| September 10 | Sept. 19 | 9 | Sept. 29 | 10 | 35 | 3.5 | 2 | 21 |
| September 10–11 | Sept. 23 | 12–13 | Sept. 29 | 6 | 16 | 2.6+ | 0 | 18–19 |
| September 11 | Sept. 21 | 10 | Oct. 31 | 40 | 50 | 1.2+ | 51 | 101 |
| September 14 | Sept. 24 | 10 | Nov. 3 | 40 | 44 | 1 + | 24–25 | 74–75 |
| September 18 | Oct. 2 | 14 | Nov. 17 | 46 | 32 | .6+ | 28 | 94 |
| September 19 | Sept. 30 | 11 | Nov. 20 | 51 | 56 | 1 + | 31 | 93 |
| September 21 | Oct. 4 | 13 | Nov. 10 | 37 | 56 | 1.5+ | 41 | 91 |
| 1907. | 1907. | | 1907. | | | | | |
| March 18 | Apr. 15 | 28 | June 6 | 52 | 48 | .9+ | 12 | 92 |
| March 19 | Apr. 16 | 28 | May 14 | 28 | 33 | 1.1+ | 2 | 58 |
| April 15 | May 16 | 31 | June 6 | 39 | 81 | 2 + | 5 | 76 |
| May 13 | May 26 | 13 | July 11 | 46 | 78 | 1.6+ | 0 | 59 |
| April 16 | May 14 | 28 | June 28 | 45 | 50 | 1.1+ | 5 | 78 |
| May 17 | May 29 | 12 | June 22 | 24 | 73 | 3 + | 8 | 44 |
| May 28 | June 11 | 14 | July 18 | 37 | 76 | 2 + | 14 | 65 |
| May 29 | June 13 | 15 | July 8 | 25 | 80 | 3.2 | 11 | 51 |
| May 30 | June 11 | 12 | July 9 | 28 | 80 | 2.8+ | 9 | 49 |
| June 11 | June 21 | 10 | July 11 | 20 | 80 | 4 | 10 | 40 |
| June 13 | June 23 | 10 | Aug. 3 | 41 | 70 | 1.7+ | 2 | 53 |
| June 24 | July 5 | 12 | ...do | 29 | 59 | 2 + | 13 | 54 |
| June 17 | June 27 | 10 | July 17 | 20 | 52 | 2.6 | 22 | 52 |
| June 23 | July 1 | 8 | Aug. 12 | 42 | 56 | 1.3+ | 0 | 50 |
| June 28 | July 6 | 8 | July 29 | 23 | 70 | 3 + | 14 | 45 |
| July 2 | July 9 | 7 | July 28 | 19 | 66 | 3.4+ | 9 | 35 |
| July 4 | Aug. 11 | 7 | Aug. 12 | 32 | 77 | 2.4+ | 10 | 49 |
| July 5 | July 12 | 7 | Aug. 8 | 27 | 85 | 3.1+ | 17 | 51 |
| July 7 | July 15 | 8 | Aug. 5 | 21 | 63 | 3 | 2 | 31 |
| July 8 | July 16 | 8 | Aug. 16 | 31 | 63 | 2 + | 17 | 56 |
| July 10 | July 19 | 9 | Aug. 8 | 20 | 67 | 3.3+ | 16 | 45 |
| July 11 | July 19 | 8 | Aug. 16 | 28 | 58 | 2 + | 17 | 53 |
| July 11 | July 20 | 9 | Aug. 27 | 38 | 50 | 1.3+ | 10 | 57 |
| July 13 | July 21 | 8 | Aug. 23 | 33 | 67 | 2 + | 7 | 48 |
| July 15 | July 22 | 7 | Aug. 24 | 33 | 72 | 2.1+ | 14 | 54 |
| July 16 | July 24 | 8 | Aug. 20 | 27 | 57 | 2.1+ | 4 | 39 |
| July 19 | July 27 | 8 | Aug. 27 | 31 | 69 | 2.2+ | 16 | 55 |
| Do | July 28 | 9 | Aug. 20 | 23 | 57 | 2.4+ | 0 | 32 |
| July 22 | July 29 | 7 | Aug. 27 | 29 | 75 | 2.6— | 9 | 45 |
| Do | July 30 | 8 | Aug. 22 | 23 | 68 | 2.9+ | 2 | 33 |
| July 24 | Aug. 4 | 11 | Sept. 8 | 35 | 69 | 2 — | 4 | 50 |
| July 28 | Aug. 6 | 9 | Aug. 27 | 21 | 70 | 3.3+ | 19 | 49 |
| July 27 | ...do | 10 | Sept. 9 | 34 | 57 | 1.6+ | 3 | 47 |
| July 29 | Aug. 7 | 9 | Sept. 1 | 25 | 80 | 3.2 | 17 | 51 |
| July 31 | Aug. 9 | 9 | Aug. 29 | 20 | 68 | 3.4 | 0 | 29 |
| July 20 | Aug. 28 | 8 | Aug. 29 | 32 | 68 | 2.1+ | 17 | 57 |
| August 5 | Aug. 13 | 8 | Sept. 15 | 33 | 81 | 2.4+ | 15 | 56 |
| August 6 | Aug. 14 | 8 | Sept. 9 | 26 | 86 | 3.3+ | 15 | 49 |
| August 9 | Aug. 18 | 9 | Sept. 8 | 21 | 63 | 3 | 0 | 30 |
| August 18 | Aug. 28 | 10 | Sept. 20 | 23 | 69 | 3 | 0 | 33 |
| August 19 | Aug. 29 | 10 | ...do | 22 | 51 | 2.3+ | 0 | 32 |
| August 24 | Sept. 1 | 8 | Sept. 24 | 23 | 52 | 2.2+ | 4 | 35 |
| August 28 | Sept. 6 | 9 | Oct. 7 | 31 | 74 | 2.3+ | 24 | 64 |
| August 31 | Sept. 11 | 11 | Oct. 22 | 41 | 69 | 1.6+ | 0 | 52 |
| September 3 | Sept. 14 | 11 | Oct. 4 | 20 | 61 | 3 + | 3 | 34 |
| September 6 | Sept. 17 | 11 | Oct. 16 | 29 | 55 | 1.9— | 39 | 79 |
| September 14 | Sept. 23 | 9 | Oct. 30 | 37 | 41 | 1.1+ | 2 | 48 |
| Averages | | 13.29+ | | 27.63+ | 61.97+ | 2.5+ | 11.5+ | 49.6+ |

As shown in Table XI, a longer time was required to reach maturity in the cooler parts of the season. The average number of days required for development during the first of the season—that is, to July 1—was 15.9+; during the warmer part of the year (July 1 to September 1) it was 8.6+; while during the period between September 1 and 21 it was 10.3 days. Both the length of life and the productive period vary in relation to temperature and season, being longest in the cooler parts of the year. The maximum period for the production of young, in my 79 experiments, was 52 days, while the average was 27.6+ days. The maximum length of life of individuals in these same experiments was 101 days and the average was 49.6+ days. Larger numbers of young are produced per day in the warmer parts of the year than in the cooler and later months. The total number of young produced by 79 females was 4,896—an average of 61.9+. The largest number of young per single female was 89, and the average number produced in one day was 2.5+. The largest number of young produced in one day by a single aphis was 9. Almost without exception, the mother aphis lived several days after the production of the last young. The number of molts was invariably 4, and, as will be seen in the accompanying table, they occurred, almost without exception, every two days.

TABLE XII.—*Periods of molts of Siphα flava, viviparous generation, 1906.*

| Date of birth. | Age at first molt. | Age at second molt. | Age at third molt. | Age at fourth molt. | Age at birth of first young. |
|---|---|---|---|---|---|
| | *Days.* | *Days.* | *Days.* | *Days.* | *Days.* |
| August 9 | 2 | 4 | 6 | 7 | 8 |
| August 4 | 1 | 3 | 5 | 6 | 7 |
| Do | 2 | 4 | 6 | 8 | 9 |
| August 12 | 2 | 4 | 6 | 7 | 8 |
| Do | 2 | 4 | 6 | 8 | 8 |

OVIPAROUS GENERATION.

The first individuals of the oviparous generation to be noticed were born September 24, 1906, although in 1905 aphides of this generation were found as early as August 25. In all cases it required a longer time for the individuals of this generation to become adults than it did for those of the viviparous generations, excepting the stem-mothers, this presumably being largely due to temperature, growth being slower in the cooler parts of the year. The length of the immature stages varied from 15 to 40 days, the latter time, however, being very exceptional in length.

TABLE XIII.—*Oviparous generation of Sipha flava, 1906.*

| When born. | Date it became adult. | Period from birth to adult. | Dates of copulation, if obtained. | Date of death or disappearance. | Total length of life. | Sex. | Remarks. |
|---|---|---|---|---|---|---|---|
| | | *Days.* | | 1906. | *Days.* | | |
| Oct. 16... | Nov. 3.... | 18 | Nov. 7.....<br>Nov. 17..... | Dec. 13.... | 57 | Male..... | |
| Do..... | Nov. 7.... | 22 | Nov. 27 (55° F)<br>Nov. 28 (54° F) | Dec. 17.... | 61 | Female.... | At least 5 eggs. |
| Oct. 12 .. | Oct. 28.... | 16 | Nov. 4.....<br>Nov. 15.....<br>Nov. 16..... | Nov. 23... | 42 | .....do .... | At least 9 eggs. |
| Oct. 14... | Oct. 30.... | 16 | ..... | Nov. 1.... | 18 | Male..... | |
| Do..... | Nov. 2.... | 19 | ..... | Nov. 28... | 45 | Female.... | |
| Oct. 15... | Oct. 31.... | 16 | Nov. 8..... | Dec. 5..... | 51 | Male..... | |
| Do..... | Nov. 1.... | 17 | Nov. 18..... | Dec. 5..... | 51 | Female.... | |
| Oct. 13... | Oct. 28.... | 15 | Nov. 4..... | Dec. 21.... | 69 | .....do .... | 12 eggs. |
| Oct. 29... | Dec. 8..... | 40 | ..... | Dec. 19.... | 51 | .....do .... | |
| | | | | 1907. | | | |
| Oct. 19... | Nov. 16... | 28 | ..... | Jan. 10.... | 83 | .....do .... | |
| | | | | 1906. | | | |
| Do..... | Nov. 17... | 29 | ..... | Dec. 21.... | 63 | ..... | |
| Oct. 9.... | Oct. 23-27. | 14-18 | ..... | Nov. 3.... | 25 | Female.... | |
| Sept. 24.. | Oct. 8-15.. | 14-21 | Oct. 18.....<br>Nov. 22..... | Dec. 12.... | 79 | .....do .... | 14 eggs. |
| Do..... | ..... | ..... | ..... | Oct. 26.... | 32 | ..... | 10 eggs. |
| Do..... | ..... | ..... | Oct. 23.....<br>Oct. 27.....<br>Nov. 7..... | Nov. 2.... | 39 | Female.... | All three aphides laid at least 22 eggs and 8 were found in their bodies. |
| Do..... | ..... | ..... | Oct. 28.....<br>Nov. 1..... | Oct. 18.... | 55 | .....do .... | |
| Do..... | ..... | ..... | Nov. 5.....<br>Dec. 3 (45° F) | Dec. 12.... | 79 | .....do .... | |
| Oct. 2.... | Oct. 18.... | 16 | Oct. 25.....<br>Oct. 30.....<br>Nov. 5.....<br>Nov. 18..... | Dec. 21.... | 81 | .....do .... | At least 11 eggs. |
| Oct. 4 (4).<br>Oct. 5 (1).<br>Oct. 6 (1). | Oct. 21 (5).<br>Oct. 22.... | 17 (4)<br>16 (1)<br>16 (1) | Nov. 3.....<br>Nov. 12..... | Nov. 3 (4).<br>Dec. 21 (2). | 30 (4)<br>77 (1)<br>76 (1) | Female (6) | Figures in parentheses refer to number of individuals. Total number of eggs laid, 31. One individual laid at least 10 eggs. |
| Average.. | ..... | 19+ | ..... | ..... | 52+ | ..... | |

The average time for the 21 cases in which an exact record was kept was 19.5 days. The sexes were first observed in copula October 18, and this was noted occasionally until December 3. At this latter date the temperature in the room where the aphides were kept was 45° F. In 1905 the earliest record of copulation was October 17, and the first eggs were found soon after. As a rule the eggs were laid on the underside of the sorghum leaf, but as might be expected there were some exceptions to this; for example, eggs were sometimes laid on the side of a cage and on the stem of a plant. November 21, 1907, at Urbana, Ill., I found oviparous females on grass, but eggs were not found. This, with the fact that the earliest spring records of finding them out of doors have been on grass, indicate that grass is the alternate food plant to which the sexuparæ migrate in the fall to produce the sexual forms. The number of eggs laid by this species varied, according to my observations, up to 14, and in 19 cases the average was 8.3 eggs per female. There was no uniform period from the laying of

one egg to that of another. Usually, however, the interval was one of several days, temperature being the controlling factor. My aphides always laid eggs until the temperature got down to 42° F. In a number of cases, upon the death of an oviparous female the body was examined, and with only one or possibly two exceptions, eggs were found therein. These facts show that there is no definite number of eggs for a sexual female to lay, but that eggs continue to be laid as long as she lives, provided the temperature is not too low. Some individuals of this sexual generation lived until January 17, 1907, though most of them died in November and December, 1906. During most of the month of December the temperature was down to the freezing point, and consequently the females were in a dormant state; as the food plants were dead they certainly obtained no food during this time. The length of life was found to vary up to 83 days, the average, however, in 17 cases, being 57.4 days. The number of molts is 4, the same in this generation as in the viviparous. Table XIV shows the periods between molts in the 7 cases of which record was made.

TABLE XIV.—*Periods of molts of Sipha flava, oviparous generation, 1906.*

| Date of birth. | Age at first molt. | Age at second molt. | Age at third molt. | Age at fourth molt. |
|---|---|---|---|---|
| | *Days.* | *Days.* | *Days.* | *Days.* |
| October 12 | 3 | 6 | 10 | 16 |
| October 13 | 3 | 5 | 9 | 15 |
| October 14 | 3 | 7 | 12 | 19 |
| Do | 3 | 6 | 10 | 16 |
| October 19 | 6 | 11 | 17 | 28 |
| Do | 6 | 12 | 18 | 29 |
| October 29 | 6 | 11 | 23 | 40 |
| Average | | | | 23+ |

## DESCRIPTIONS.

### *Sipha* (*Chaitophorus*) *flava* Forbes.

This aphis does not belong to the genus *Chaitophorus*, which has 6 antennal segments (or 7, counting the filament), and should doubtless be placed in the genus *Sipha* of Passerini, which is described as having 5 antennal segments, or 6 with the filament, the third segment and filament longest; the cornicles tuberculiform.

#### VIVIPAROUS GENERATION.

*Before first molt and less than 24 hours old.*—Citron-yellow throughout. Legs and antennæ somewhat transparent and of a lighter tint than the body color. Antennæ apparently only 4-segmented. One sensorium is present at the extremity of the third segment. Eyes brownish red. Numerous tuberculate spines on the

body, which are regularly distributed in longitudinal rows, there being 6 conspicuous rows in all, 4 dorsal and 2 lateral. Measurements when not more than 2 hours old: Length of body, 0.618 mm.; width, 0.290 mm.; antenna, 0.270 mm.; lateral spines, 0.072 mm. Not more than 24 hours old: Length of body, 0.690 mm.; width, 0.309 mm.; antenna, 0.290 mm.; lateral spines, 0.072 mm.

The young from eggs differ from the above (those born alive) in that the general color is a dark green, with black spinal markings and with black rings around the cornicles.

*After first molt and 48–72 hours old.*—General color citron-yellow. Eyes brownish red. Antennæ as before molt, except that there is now a slight constriction near the distal end of the third segment, where it later divides into 2 distinct segments; also, the circular sensorium of the distal end of the third is on a tubercle or short stalk-like process, and at the apex of the thickened base of the fourth segment is another circular sensorium. Five dark lines occur around the openings of the inconspicuous cornicles. Markings as before. Measurements: Length of body, 1.05 mm.; width, 0.49 mm.

*After second molt and 60–84 hours old.*—General color canary-yellow. Eyes brownish red. There are still only 4 distinct segments of the antennæ, and the constriction of the third segment is more distinct. Cornicles more distinct than in the earlier stages. Measurements: Length of body, 1.45 mm.; width, 0.56 mm.; antenna, 0.43 mm.

*After third molt and 124–148 hours old.*—General color canary-yellow. Eyes brownish red. The constriction of the third antennal segment becomes more distinct. Cornicles more distinct and almost as fully developed as in the adult. Measurements: Length of body, 1.96 mm.; width, 0.74 mm.; antenna, 0.63 mm.; abdominal bristles, 0.127 mm.

*Adult wingless viviparous female.*—General color canary-yellow. Eyes brownish red. Antennæ of the same general tint as the body, excepting the last segment, which is darkened; 5-segmented and sparsely hairy, but the few hairs or bristles present conspicuous. Beak short, not extending farther than the coxæ of the middle pair of legs. Six conspicuous bristles project forward from the front of the head and between the bases of the antennæ. Several less conspicuous hairs are found below those just mentioned. Dorsally are 4 longitudinal curving rows of black transverse markings, 2 rows on each side of the median line. Ten longitudinal rows of erect tubercular bristles are present on the dorsal and dorso-lateral sides of the thorax and abdomen. Cornicles short truncated cones, inconspicuous except for the dark ring around the opening. Measurements: Length of body, 1.818 mm.; width, 0.763 mm.; antenna, 1,

0.049 mm.; II, 0.049 mm.; III, 0.236 mm.; IV, 0.147 mm.; V, basal, 0.130 mm.; filament, 0.244 mm.; total, 0.855 mm.

*Pupa of winged viviparous female.*—Head and thoracic segments olive-yellow; abdomen pale yellow, with greenish tint. Eyes dark red. Antennæ 5-segmented, all except last segment concolorous with head. Antennæ and head with bristles, as in other forms. Thorax with several dark-green patches from which arise tuberculate bristles. Legs, excepting tarsi, which are black, concolorous with body. Wing-pads light brown. Abdomen with 8 longitudinal rows of tuberculate spines, each spine with a basal patch of dark green. A longitudinal row of small transverse dashes occurs on each side between the first and second rows of spines, counting from the median line. Cornicles as in the other forms, and with dark-green basal patches. Measurements: Length of body, 1.953 mm.; width, 0.863 mm.; antenna, I, 0.058 mm.; II, 0.048 mm.; III, 0.194 mm.; IV, 0.135 mm.; V, basal, 0.107 mm.; filament, 0.214 mm; total, 0.750 mm.

*Winged viviparous female.*—Head and abdomen lemon-yellow, with the thoracic segments brownish. Eyes red. Antennæ with several more or less noticeable hairs, much less conspicuous than in the wingless pseudogyne; all except the two basal segments and the basal half of the third segment are dark; a single circular sensorium at apex of fourth segment and several at the apex of the basal portion of the fifth segment. Beak hardly reaching to the coxæ of the second pair of legs. Head and thorax with spinous tubercles much as in the wingless pseudogyne. Legs concolorous with body, excepting tips of tarsi, which are darkened. Stigma and cubitus pale yellow, other wing-veins dusky. Abdomen with 8 longitudinal rows of dark-green spots from which arise conspicuous tuberculate spines. Between the first and second rows of spots from the median line, on each side, is a row of small dark dashes. Cornicles tuberculiform, and with dark-green basal patches. Style slightly constricted in the middle. Measurements: Expanse of wings, 5.744–6.477 mm.; length of body, 1.641 mm.; width, 0.734 mm.; antenna, I, 0.065 mm.; II, 0.065 mm.; III, 0.277 mm.; IV, 0.196 mm.; V, basal, 0.147 mm.; filament, 0.293 mm.; total, 1.043 mm.; style, 0.088 mm.

OVIPAROUS GENERATION.

*Before first molt and 24–48 hours old, male or female.*—Color sulphur-yellow. Head with a dark patch covering it almost entirely. Eyes red. Antennæ and legs transparent until a day old, gradually darkening until they become concolorous with the darker markings of the body. Antennæ apparently only 4-segmented, a constriction in the apical half of the third segment showing where this segment later divides into two. At the distal end of the third segment is a

distinct sensorium, while at the apex of the thickened base of the fourth are one or more indistinct sensoria. Thorax with dark patches covering about one-half of the dorsal surface. Abdomen with dark markings which appear only after the aphis is at least one day old. Abdomen with 4 distinct dorsal rows of tuberculate spines, 2 on either side of the median line, and at least 1 lateral row on each side. At the base of each of these spines is a small darkened area. The small indistinct cornicles are surrounded with dark circular patches. The opening also is marked by a dark ring. Measurements: Length of body, 0.763 mm.; width, 0.362 mm.

*Female after second molt and 7 or 8 days old.*—General color light apple-green. Antennæ lighter than body color excepting second segment and tip of last segment. Spine spots bice-green in color. Tarsi black. Measurements: Length of body, 1.331 mm.; width, 0.581 mm.; antenna, 0.537 mm.

*Female after third molt.*—General color apple-green, becoming paler and with a yellowish tinge at the caudal end. Head lighter than body color. Eyes reddish brown. Antennæ pale, excepting the last segment, which is darkened. That segment which in the earlier stages represents the third is now indistinctly separated into 2 segments. The sensorium at the distal end of the fourth (the third of the earlier stages) is quite distinct. The apex of the thickened base of the last segment has numerous distinct sensoria. Legs pale, excepting tarsi, which are black. Cornicles more distinct. Measurements: Length of body, 1.775 mm.; width, 0.725 mm.

*Adult wingless oviparous female.*—Head, first 2 thoracic segments, and tip of abdomen oil-green in color. Abdomen parrot-green, shading at extremities to oil-green. Eyes dark reddish-brown. Antennæ 5-segmented; 1 sensorium at distal end of fourth and several at the end of basal part of the fifth; bristles few but conspicuous, there being 2 on each of the 2 basal segments, 3 or 4 on the third, and 1 on the fourth. Projecting forward from the head and between the bases of the antennæ are 6 distinct bristles. Beak short, not extending farther than the coxæ of the second pair of legs. On the dorsal surface of the body are 4 rows of small transverse dashes, 2 on each side of the median line; also 8 rows of tuberculate bristles, 4 on each side of the median line. Hind tibiæ noticeably swollen and bearing numerous circular sensoria. Style upcurved. Cornicles as in all the other forms of this species. Measurements (alcoholic specimens): Length of body, 1.67–1.92 mm.; width, 0.72–0.83 mm.; antenna, I, 0.065 mm.; II, 0.065 mm.; III, 0.244 mm.; IV, 0.130 mm.; V, basal, 0.106 mm.; filament, 0.236 mm.; total, 0.846 mm.; style, 0.078 mm.

*Male after second molt and 8 or 9 days old.*—General color citron-yellow. Antennæ 5-segmented. Sensoria at end of fourth and at

distal end of the thickened base of the fifth segment. Measurements: Length of body, 1.098 mm.; width, 0.469 mm.

*Male after third molt.*—General color sulphur-yellow, shading to greenish at extremities. Eyes brownish red. Other markings as in earlier stages. Measurements: Length of body, 1.603 mm.; width, 0.744 mm.; antenna, I, 0.067 mm.; II, 0.057 mm.; III, 0.162 mm.; IV, 0.133 mm.; V, basal, 0.095 mm.; filament, 0.191 mm.; total 0.705 mm.

*Adult male.*—General color bright lemon-yellow. Eyes dark reddish brown. Antennæ usually as long as body, the two basal segments concolorous with the body and the others dark; antennæ with a few conspicuous hairs, there being 2 on each of the two basal segments, 5 on the third, and either 1 or 2 on the fourth; circular sensoria numerous (at least 40) and irregularly placed on the third, 15 to 20 on the fourth, and a number at the distal end of the thickened base of the fifth segment. Beak short, not reaching farther than the coxæ of the second pair of legs; its tip dark, the rest concolorous with the body. Six distinct bristles project forward from the front of the head and between the bases of the antennæ. On the dorsal surface of the body are 8 rows of tuberculate bristles, 4 on each side of the median line. There are also 2 rows of dark oval markings on each side of the median line. Measurements (alcoholic specimens): Length of body, 1.12–1.30 mm.; width, 0.45–0.50 mm.; antenna, I, 0.081 mm.; II, 0.065 mm.; III, 0.407 mm.; IV, 0.220 mm.; V, basal, 0.106 mm.; filament, 0.350 mm.; total, 1.229 mm.

*Eggs.*—Color, when first laid, pale green, with a small dark spot of obscure form showing through the egg-shell at one end. The egg gradually darkens until it becomes a jet-black. There is no noticeable change in color just before the young hatch. Form elliptical-oval. Measurements: Length, 0.652 mm.; width, 0.3015 mm.

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Food plants of *Chaitophorus flavus* Forbes given as cultivated corn, cultivated sorghum, and *Sorghum halpense* L.

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